RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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THE GEOLOGICAL SURVEY OF INDIA.

1915. [August

QUINQUENNIAL REVIEW OF THE MINERAL PRODUCTION OF INDIA. BY SIR THOMAS H. HOLLAND, K.C.I.E., D.SC., F.R.S., AND L. LEIGH FERMOR. REVISED FOR THE YEARS 1909 TO 1913 BY H. H. HAYDEN, C.I.E., D.SC., F.R.S., *Director,* AND L. LEIGH FERMOR, D.SC., A.R.S.M., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 1 to 8.)

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I.—INTRODUCTION.

THE first Review of the Mineral Production of India that was published by the Geological Survey appeared in Part I, Vol. XXXII of these *Records* and surveyed the progress made in the years 1898 to 1903. Subsequently, annual reviews have been published each year, and a quinquennial review after periods of five years; the second quinquennial review covered the years 1904 to 1908 and the present issue deals with the period 1909 to 1913. The general scheme of the Review as evolved by Sir Thomas Holland and Dr. Fermor has been retained for the present, since it embodies a considerable amount of useful information with regard to the occurrence in India generally of minerals of economic value. It is proposed to supersede the latter part by a Bibliography of Indian Economic Geology, which is now in course of preparation and will be issued shortly; it will then be possible to restrict this Review to comparison and discussion of the actual figures. For the present, however, it is desirable that the work should retain its more complete form.

In the first Review it was explained that although many valuable mineral products were being worked in different parts of the country it was impossible to obtain statistics about some of them sufficiently precise to be of any value as figures. The most conspicuous of these 'minerals' are the various forms of building material and slate, which are naturally used extensively in every district and would form an excellent index of material progress if we could rely on the figures returned, and could regard those of one period as fairly comparable with those of another.

Grouping of the minerals.

In order to obtain some mental impression of progress, we are compelled to exclude from the list of minerals contributing to the statement of total values, those about which we can obtain only partial figures or rough local estimates. The minerals are thus reviewed in two groups as before, namely—

Group I.—Those for which approximately trustworthy annual returns are obtainable; and

Group II.—Those regarding which regularly recurring and full particulars cannot be procured.

As the methods of collecting the returns become more precise from year to year and the machinery employed for the purpose becomes more efficient, the minerals included in Group I tend to increase in number, and to those included in that group when the last Quinquennial Review was published we are now in a position to add monazite, lead, silver and tungsten. Group I, therefore, now comprises:

Chromite.	Manganese.
Coal.	Mica.
Diamonds.	Monazite.
Gold.	Petroleum.
Graphite.	Ruby, Sapphire and Spinel.
Iron.	Salt.
Jadeite.	Saltpetre.
Lead.	Silver.
Magnesite.	Tin.

Tungsten.

Units recognised.

Unless otherwise stated, the *ton* referred to in this Review is the English statute ton of 2,240 lbs. Where there are totals likely to be of interest to foreign readers weights are also expressed in metric tons of 1,000 kilogrammes each (equal to 0·984 statute ton). Returns in *maunds* have been translated into tons, cwts. and qrs. throughout. The output of petroleum has been given in Imperial gallons and totals are expressed also in *metric tons* assumed to be equivalent to 249 gallons of crude oil of an average specific gravity of 0·885. Values are given in sterling calculated throughout at the rate of Rs. 15=£1, which has been the fixed rate of exchange throughout the period of this and the previous Reviews.

Sources of information.

The data employed in this Review have been obtained from various sources. Previous to 1904 the Annual Statistics of Mineral Production were published by the Director-General of Statistics. Since then the figures of mineral production for India have been published annually in the Records of the Geological Survey of India. During a part of the period the annual figures were supplied by the Local Governments to the Director-General of Commercial Intelli-

gence, who passed them on to the Geological Survey; but as this did not allow of a thorough and prompt check on the figures, a change was introduced beginning with 1907, and now all returns of mineral production are sent by Local Governments and Political Agents direct to the Geological Survey Office, except in the case of mines under the Mines Act, when the figures are forwarded direct by the managers of the mines to the Chief Inspector of Mines, who forwards a summary to the Geological Survey. Information regarding ex ports and imports has been taken from the publications issued by the Director-General of Statistics. Additional information has been obtained from the following sources:—

(1) Annual Returns of the Chief Inspector of Mines in India and the Chief Inspector of Mines for Mysore;
(2) Annual Returns of the Gold Mining Companies of the Kolar, Dharwar and Hutti Fields, kindly supplied by the Managing Agents;
(3) Annual Administration Reports of the various Local Governments and Local Administrations in India;
(4) Annual Administration Reports of the Railway Board;
(5) Returns issued by the various Geological Surveys, and Statistics relating to Mines and Quarries, published by the English Home Office.

We are also indebted to the Managing Agents of several Mining Companies for much information supplied direct.

II.—SUMMARY OF PROGRESS.

Total values.

The following table summarises the values of the principal minerals produced during the five years under review. The totals have the obvious defect of being due to the addition of unlike denominations; for export values, being the only returns obtainable in some cases, are ranged with spot values, while the latter necessarily vary with the position of the mine, representing not the *values* but the *prices* obtainable. In the case of coal, for instance, the so-called value of a ton of good coal in Bengal is less than half that of the inferior material raised in Baluchistan ; in the case of salt the values given are the prices charged, and these, on an average, are but one-seventh of the duty, which is the principal value of the salt to Government ; certain valuable mineral products, such as building stones, are omitted altogether, for want of any but very approximate estimates.

The values returned for minerals exported are also necessarily lower than they would be if the minerals were consumed in the country and it is consequently unfair to compare this table of values with corresponding returns for countries in which metallurgical industries flourish. Manganese-ore is a conspicuous example of a product which, according to its quality, may be worth 30 to 40 shillings a ton to the European steel-maker, but which is of less value to the Indian producer by the heavy cost of transport. The country is thus not only so much poorer by the loss of the metal exported in the ore, but is paid in return little more than half its market value.

Comparison with the previous period.

The imperfections of the table are those confessedly inseparable from all such estimates of mineral production ; and it is of use merely as a means of comparing one year with another, the same system being carried through the whole period under review. In the period of the previous Review there was a steady uninterrupted progress in production from a total of £5,364,016 in 1904 to £7,880,832 in 1908, an increase of 56·14 per cent. in five years. There was a slight fall in the totals during the succeeding year 1909. This was due to the disturbance of normal conditions in 1907 and 1908 by the coal 'boom,' and the consequent depression ;

but matters soon righted themselves and in 1910 the total value of the mineral output had recovered about a quarter of the ground lost. Owing to a considerable decrease in the exports of manganese-ore the figures for 1911 again fell to a little below those for 1910. In the following year, however, there was a very large increase in value from a little over 7½ million pounds sterling to nearly 9 millions, while the last year of the period under review shows a still further increase, to a little under £10,000,000.

TABLE 1.—*Total Value of Minerals for which Returns of Production are available for the years 1909 to 1913.*

Mineral.	1909.	1910.	1911.	1912.	1913.	*Average for the period 1909-1913.*
	£	£	£	£	£	£
Coal	2,779,865	2,455,544	2,502,616	3,310,365	3,708,137	*2,969,305*
Gold	2,204,866	2,202,486	2,238,143	2,271,806	2,291,917	*2,241,844*
Petroleum	910,172	835,927	884,398	975,278	1,034,586	*928,072*
Manganese-ore (*a*)	515,260	729,312	621,277	972,066	1,276,465	*822,876*
Salt (*b*)	450,573	565,078	469,292	510,081	541,447	*507,294*
Saltpetre (*c*)	296,838	230,615	230,809	205,600	237,581	*240,289*
Mica (*c*)	156,199	177,152	188,642	284,290	347,451	*230,747*
Lead-ore and Lead	74,228	163,022	181,996	153,069	71,597	*128,782*
Tungsten-ore	579	38,873	99,989	115,200	127,762	*76,481*
Ruby, Sapphire, and Spinel	61,826	58,849	67,594	69,547	55,542	*63,272*
Jadestone (*c*)	91,401	99,601	29,815	19,853	36,194	*55,373*
Monazite	..	..	24,044	41,419	42,012	(*d*) *35,825*
Tin-ore and Tin	9,645	18,578	24,931	50,944	46,401	*30,100*
Iron-ore (*e*)	16,563	9,811	34,496	47,044	39,680	*29,519*
Graphite	12,529	20,479	16,080	..	..	(*d*) *16,363*
Silver	2,996	4,968	11,575	11,829	15,338	*9,341*
Chromite	7,737	2,315	5,072	3,849	2,435	*4,282*
Magnesite	196	1,382	1,047	4,614	4,776	*2,403*
Diamonds	1,089	590	478	411	1,791	*872*
Amber	287	283	133	179	29	*182*
TOTAL	**7,595,849**	**7,614,865**	**7,632,427**	**9,047,444**	**9,971,141**	*8,393,222*

(*a*) Export values of quantities actually exported.
(*b*) Prices without duty.
(*c*) Export values.
(*d*) Average for 3 years.
(*e*) Estimated values for provinces other than Bengal, Bihar and Orissa.

The increase during the whole quinquennial period amounts to a little over £2,000,000, or a rise of just over 25 per cent. This rise is due to two factors, (*a*) the progress of industries already established, and (*b*) the creation of new industries. In the former category the most prominent minerals are coal, petroleum, manganese, salt, mica and, to a less extent the ores of iron and tin. In the second category we find lead with its associated silver, monazite, and tungsten,—all practically new industries, although one, that of the silver-lead of Bawdwin, first contributed to the list in the last year of the preceding period.

Of other minerals the value of the output has remained more or less stationary; the most important of these is gold. A few minerals have shown a steady falling away, but as a rule these do not represent large industries; they are saltpetre, jadestone, rubies, and graphite, the outputs of all of which have declined appreciably, while the graphite industry is at present extinct.

In the previous Review, Sir Thomas Holland wrote:

The neglect of metalliferous ores.

"The principal reason for the neglect of metalliferous minerals is the fact that in modern metallurgical and chemical developments the bye product has come to be a serious and indispensable item in the sources of profit, and the failure to utilize the bye-products necessarily involves neglect of the minerals that will not pay to work for the metal alone. Copper-sulphide ores are conspicuous examples of the kind: many of the most profitable copper mines in the world could not be worked but for the demand for sulphur in sulphuric acid manufacture, and for sulphuric acid there would be no demand but for a string of other chemical industries in which it is used (*cf.* page 295). A country like India must be content, therefore, to pay the tax of imports until industries arise demanding a sufficient number of chemical products to complete an economic cycle, for chemical and metallurgical industries are essentially gregarious in their habits." This is still as applicable as it was five years ago, but there are signs that before long endeavours will be made to remove this reproach.

During the period under review the Tata Iron and Steel Works at Sakchi have at last become firmly established and they now produce an appreciable proportion of the steel rails employed in India. Neither the wolfram nor the monazite, both of which have formed the bases for new industries, has received metallurgical treatment

in India, practically the whole output of each having been exported in the raw state to Germany. On the other hand, considerable attention has been paid to the development of copper-mining with a view to smelting in India and schemes have been propounded for the local treatment of the bauxite of the Central Provinces; it is to be hoped therefore that the next quinquennium will see the final success of one or both of these projects.

During the period under review a certain amount of serious attention has been given to the development of bauxite, copper ore, and lead-silver ores, and it is probable that during the quinquennial period, 1914 to 1918, the smelting of some of these ores in the Indian Empire will become firmly established. The most promising province in this respect is Burma, where the smelting of lead slags from Bawdwin commenced in 1909 (see page 127).

Comparison with foreign mineral production.

Although such great progress has been made during the period under review in the development of the mineral resources of India, the relative insignificance of the total value will be seen by comparing the figures for 1912 in table 1 with those for the twelve most important mineral products of the United Kingdom, the United States of America, and the German Empire given in table 2. From this it will be seen that the value of the coal produced in the United Kingdom was thirteen times the value of the total Indian mineral production; the value of each of ten out of the twelve leading minerals of the United States exceeded the total Indian production; whilst the value of the German coal production was eleven times that of the Indian mineral total, and that of potassium and magnesium salts nearly two million sterling more (see table 2 on page 12). A factor of great importance to the mineral development of the country is the output of building material, such as clay, slate, and building stones. This is clearly illustrated in the case of the United Kingdom, where stone, clay, and shale, and slate, rank respectively 3rd, 4th and 6th in order of value; and in the United States, where clay products rank 4th, 'stone' ranks 8th, and cement 9th in order of value, the value of the clay products alone, by which is meant clay, bricks, tiles, pipes, etc., being more than four times the value of the total Indian production. In the case of Germany no figures for these substances are available and consequently none appear in the table. It will further be noticed what an important part in the mineral production

of each of the three countries cited is played by the ores of the metals used in the arts, such as those of iron and lead in all three countries, of copper and zinc in two of the countries, and of gold, silver, and tin, each in one country.

TABLE 2.—*Values during 1912 of the Twelve Leading Mineral Products in the United Kingdom, United States, and Germany.*

United Kingdom. (*a*)		United States of America. (*b*)		German Empire. (*a*)	
	£		£		£
Coal	**117,921,123**	Coal	**142,834,922**	Coal including brown coal.	**100,778,250**
Iron-ore	3,763,837	Pig-iron	**86,357,985**	Potassium and magnesium salt excluding alum.	**10,744,800**
Stone (*c*)	3,548,831	Copper	**42,123,067**	Iron-ore	5,506,650
Clay and shale	1,633,736	Clay products	**35,484,861**	Zinc-ore	2,614,850
Tin-ore (dressed)	1,012,290	Petroleum	**33,634,976**	Copper-ore	1,596,800
Slate	972,022	Gold	**19,189,220**	Salt (Sodium Chloride).	1,188,800
Oil Shale	765,730	Natural gas	**17,364,262**	Lead-ore	982,100
Salt	577,473	Stone and slate	**17,315,789**	Petroleum	472,650
Lead-ore	295,614	Cement	**13,852,467**	Arsenic ore	135,000
Chalk	190,799	Zinc	9,178,474	Iron pyrites	101,900
Gravel and sand	167,610	Silver	8,048,768	Asphalt	41,250
Gypsum	110,591	Lead	7,676,704	Cobalt, Nickel and bismuth ores.	36,700

(*a*) Value at mine or quarry.
(*b*) Value at place of production.
(*c*) Including Limestone, Sandstone and Igneous Rocks.

Imports of minerals and mineral products.

In this place, also, it will be interesting to note the values recorded for imported minerals and for products obtained directly from minerals, during the period under review. These figures, exclusive of the values of cutlery and hardware, machinery and millwork, railway plant and rolling stock, earthenware and porcelain, glass and glassware, jewellery and plate of gold and silver, paints and colours, and alizarin and aniline dyes, are shown in table 3. From this table it will be seen that the imports of minerals and products directly obtained from minerals have increased from £14,478,744 in 1908 to £20,743,199 in 1913, the average annual value being £15,855,530. If the figures in the last column, showing the average values for the period 1909-13, be compared with the average figures for the five years 1904-08 given on page 13 of Volume XXXIX of these *Records*, it will be seen that there has been an increase, during the five years under review, of nearly £4,000,000 over the average of the previous period, and that this increase has been distributed over all the items, with the exception of lead and German silver, in which there has been

a decrease in the average annual value of £15,823 and £8,661, respectively. The chief increases in the average annual imports have been in copper, iron, and steel, the amounts of increase being £584,568 for copper, £1,859,304 for iron and steel combined.

TABLE 3.—*Value of Imports of Minerals and Products obtained directly from Minerals for the years 1909 to 1913 (including Government stores).*

——	1909.	1910.	1911.	1912.	1913.	*Average.*
	£	£	£	£	£	£
Salt . . .	484,643	463,408	554,011	548,712	570,457	*524,246*
Metals—						
Brass . .	72,547	74,829	72,309	70,986	129,143	*83,963*
Copper . .	1,693,279	2,260,298	2,239,132	1,468,069	2,690,548	*2,070,265*
German silver .	115,182	122,716	112,551	93,080	133,411	*115,388*
Iron . .		373,210	349,846	371,220	419,702	
Iron or steel .	5,816,405	5,183,109	5,269,401	5,985,542	8,028,182	*7,322,902*
Steel . .		940,558	1,154,503	1,028,338	1,694,495	
Lead . .	134,494	133,733	107,923	130,905	151,568	*131,725*
Quicksilver .	24,318	35,693	22,635	39,604	30,578	*30,566*
Tin . .	286,614	306,491	331,960	329,497	441,010	*339,114*
Zinc . .	108,472	117,798	134,081	173,034	186,085	*143,894*
Unenumerated .	139,042	137,023	194,755	294,940	319,252	*217,002*
Total of Metals .	**8,390,353**	**9,685,458**	**9,989,096**	**9,985,215**	**14,223,974**	*10,454,819*
Inorganic Chemicals.	554,306	597,708	685,483	654,953	698,442	*638,178*
Mineral oil and Paraffin.	2,258,144	2,161,833	2,753,493	2,393,683	2,629,985	*2,439,428*
Coal, coke and Patent Fuel.	600,455	394,237	398,012	736,842	1,091,809	*644,271*
Precious stones and Pearls unset.	548,665	511,565	591,397	717,515	746,510	*623,130*
Stone and Marble.	26,481	25,593	24,806	25,493	37,695	*28,014*
Other Building Materials.	394,932	450,306	425,430	502,224	744,327	*503,444*
TOTAL .	**13,257,979**	**14,290,168**	**15,421,728**	**15,564,637**	**20,743,199**	*15,855,530*

But in addition to the imports of minerals and of products obtained directly from minerals shown in table 3, there is a large import of products of a more finished nature manufactured either entirely or almost entirely from minerals or mineral products. The average value of the imports of these is almost as high as that of the items given in table 3; in order to indicate the nature of

these imports of more finished products, we give below the figures for the last five years of the most important of these imports.

TABLE 4.—*Value of Imports of products of a more finished nature manufactured almost entirely from minerals or mineral products for the years 1909 to 1913 (including Government stores).*

—	1909.	1910.	1911.	1912.	1913.	*Average.*
	£	£	£	£	£	£
Railway Plant and Rolling stock.	6,254,536	3,654,743	4,627,259	5,432,748	8,622,887	*5,718,436*
Machinery and Millwork.	4,097,346	3,408,064	3,245,496	3,468,397	5,174,059	*3,878,672*
Cutlery and Hardware.	2,015,228	2,115,635	2,351,355	2,566,315	3,006,104	*2,410,927*
Glass and Glass-ware.	828,077	1,005,672	1,018,784	1,105,937	1,330,470	*1,057,788*
Alizarine and aniline dyes.	543,683	685,596	603,067	729,099	747,704	*661,830*
Paints and Colours	284,026	334,261	333,862	375,371	423,747	*350,254*
Earthenware and Porcelain.	283,227	310,773	337,345	359,233	412,693	*340,654*
TOTAL .	**14,306,123**	**11,514,744**	**12,517,168**	**14,037,100**	**19,717,664**	*14,418,560*

It will be seen that some of the items, specially the first, vary considerably from year to year, but the average annual value for the quinquennial period was £14,418,560. It will also be seen from these figures that the total value of the imports of minerals and products obtained directly from minerals, and of the articles manufactured from these, was over £30,000,000, whilst the average annual value of the mineral production of the country was not quite £8,500,000. It is evident, therefore, that there is a demand in India for products manufactured ultimately from minerals to the annual value of nearly four times the annual value of mineral production. This indicates better than any other figures the scope there is for the development of the mineral industries of India for the supply of the internal consumption of the country, quite apart from any markets that might be supplied abroad. That India, in many cases, possesses the mineral resources requisite for the supply of this demand can be gauged from the substance of this review.

Comparison of imports with production.

Summary for the Minerals of Group I.

Chromite.

The production of chromite has averaged 3,234 tons annually, valued at £3,633 during the period under review. This is rather less than half the average output of the previous quinquennium. The figures

for that period, however, were unduly affected by the sudden rise of the output from a little over 4,000 tons in 1906 to over 18,000 in 1907 in consequence of the extraction of a very large quantity in Mysore State; as only about 200 tons of this were exported during the year, the output could not be regarded as a true indication of the condition of the industry, and if we set aside the figures for 1907, the average annual output for the period becomes 3,856 tons, which is not very different from the average for the period 1909-13.

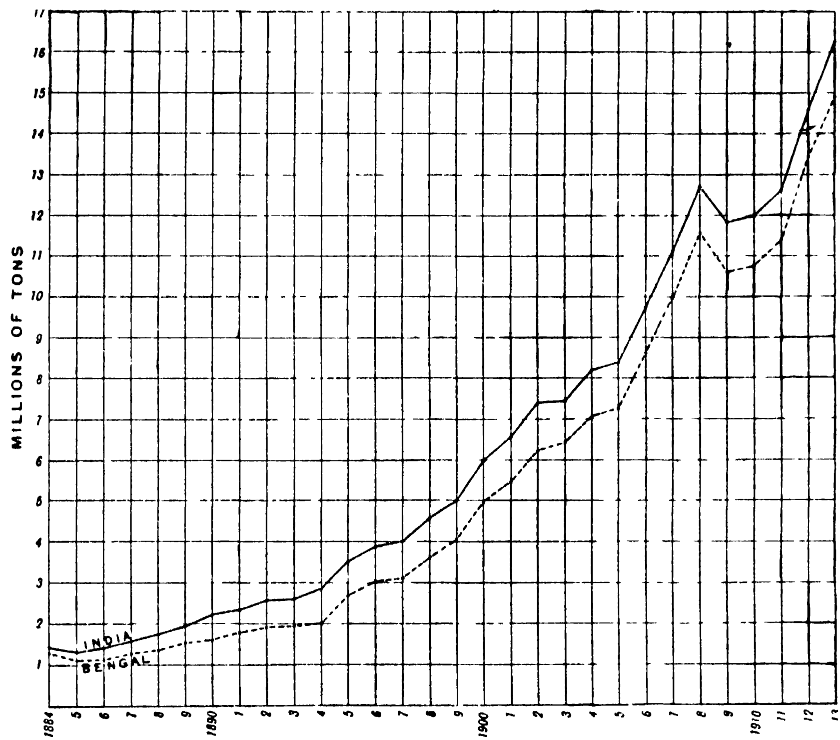


FIG. 1.—*Production of Coal from 1884 to 1913.*

Coal.

In the case of coal, the continuous increase in the Indian output received a slight check during the first two years of the period under review. This was due to the effects of the 'boom' of 1908, the last year of the preceding quinquennium, when not only did the output increase by 1½ million tons, but the value rose to an abnormal figure. This resulted in temporary over-production with a subsequent

'slump,' with the effect that the pit's mouth value, which had risen from Rs. 2-8-0 in 1905 to Rs. 3-15-0 in 1908, fell to Rs. 3-1-0 in 1910 and to Rs. 2-15-0 in 1911. By 1911, however, the industry had righted itself, and since then there has been a steady advance both in output and in price. The output in 1913 was almost exactly double that of 1904, the first year of the previous quinquennial period, namely, 16,208,009 tons as against 8,216,706 tons (see fig. 1, page 15).

In 1902 the Indian output for the first time was the highest of that of any of the British dependencies, and from that time India has steadily increased its ascendancy, her output for 1913 being nearly two million tons greater than that of any one of the three chief producers, Australia, Canada and South Africa. The rate of increase of output has, however, been much more rapid in Canada than in India during the last five years and it is probable that that country will soon occupy the first place. By far the larger proportion of this increase in the Indian coal production has been obtained from the Jherria coalfield, the output of which has grown from 750,000 tons in 1898 to over 8½ million tons in 1913; being in that year 53·11 per cent. of the total Indian production. At the same time the output of the Bengal[1] fields increased from 78·6 per cent. of the Indian total in 1898 to 85·5 per cent. in 1903, 90·5 per cent. in 1908 and 91·8 per cent. in 1913.

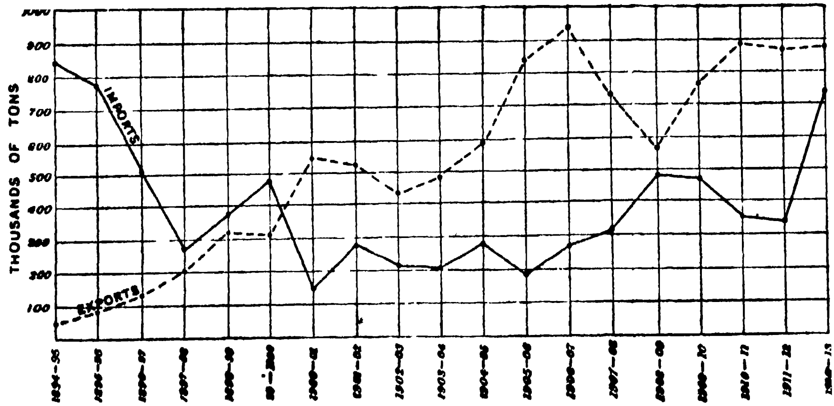


FIG. 2.—*Exports and Imports of coal for the past 20 years.*

[1] The term 'Bengal' is employed in its old sense to embrace all the fields formerly in Bengal, but now in great part transferred to the new province of Bihar and Orissa.

The greater part of the steady increase in production must be ascribed to the normal development of trade, for up to 1913 there had been no appreciable development of the metallurgical industry within range of the coalfields and the general nature of the coal-consuming industries had not changed. Thus the quantity of Indian coal consumed on the railways increased from 1½ million tons in 1898 to 3½ million tons in 1908 and about 5 millions in 1913, whilst the Indian coal consumed on railways has formed over 31 per cent. of the total production during the period now under review, this being higher than the figure for the previous period 1904-08, and indicating that railway expansion has, if anything, outstripped the coal-consuming industrial enterprises.

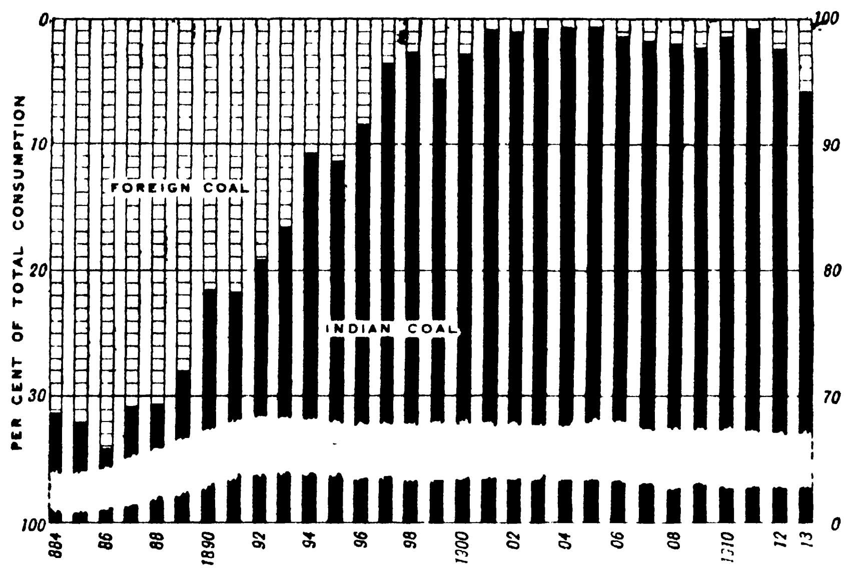


FIG. 3.—*The relative consumption of Foreign and Indian coals on Indian Railways during the 30 years 1884 to 1913.*

The imports of foreign coals which, during the previous quinquennium, had ranged between 200,000 and nearly 500,000 tons, rose considerably to over 730,000 tons at the latter part of the period under review (see fig. 2, page 16); while the percentage of foreign coal used on the railways rose from 2·1 of the total amount consumed, the highest figure in the preceding period, to 2·3 in 1909, 2·5 in 1912 and 5·9 in 1912-13 (see fig. 3, page 17). At the same time the

exports remained fairly constant, ranging as before from over 500,000 to nearly 900,000 tons. This shows that there has been a very considerable increase in the consumption of coal in India.

Diamonds.

The average annual production of diamonds has fallen from 306·7 carats valued at £2,799 in the previous quinquennium to 84·3 carats valued at £872 in the present period, in spite of a small production from Karnul and Banganapalle in the Madras Presidency. The Central Indian State of Panna ceased to be a producer, but, on the other hand, there was in 1913 a small output from the States of Bijawar and Baraunda. Attempts are being made to organise the working of both the Central India and the Karnul occurrences by modern methods.

Gold.

The output of gold reached its highest point—631,116 ounces—in 1905, after which there was a slight decline to 567,780 ounces in 1908. During the period under review the annual output has varied but little, there having been a small but steady rise from 573,120 ounces in 1910 to 595,761 ounces in 1913. The changes in the Indian gold production since 1890 are shown in fig. 4.

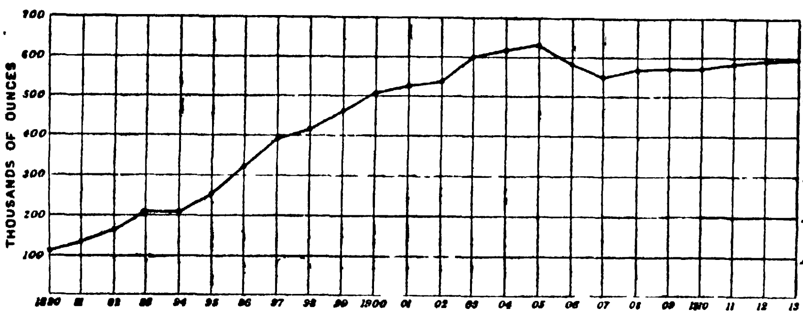


FIG. 4.—*Production of gold since 1890.*

Mining continues at the Hutti mine in the Nizam's Dominions, with a steady production of gold. The Dharwar field, however, has been a disappointment and work there was closed down in 1912. The Anantapur mine in Madras has given much more promising results and the output rose from 2,532 ounces in 1910 to over 11,000 ounces in 1913. There has also been continuous production by the Burma Gold Dredging Company operating on the upper reaches of the Irrawaddy river; the results have been better than those for the preceding quinquennium, but are disappointing nevertheless.

Graphite.

We have unfortunately to record the extinction in the period under review of the graphite-mining industry of India. This was confined to the Travancore State, where the mines worked by the Morgan Crucible Company closed down in 1912, although the value of the material raised in 1910 was higher than that raised in any year during the preceding quinquennium.

Iron.

An important advance was made in the development of Indian industrial enterprise by the opening of the works of the Tata Iron and Steel Company at Sakchi in February, 1911. There are now, therefore, in India two plants turning out iron on European lines, the Barakar Iron Works and the Tata Iron and Steel Company, of which the former has received fresh impetus from the discovery of a new source of ore in Manharpur.

The native charcoal-iron industry continues to flourish in some of the more remote parts of the Peninsula, but particularly in the Central Provinces, where there have been, on an average, during the period under review, 428 small direct-process furnaces at work annually.

During the five years 1909-13, the average value of the annual imports of unfinished and finished iron and steel has been £19,330,936 as against £16,910,432, the average for the previous five years. The value of the pig iron, iron bars, and steel bars, sheets and beams, increased from nearly 6 millions in 1909 to 10 millions in 1913, with an average annual value for the period of nearly 7½ millions, the differences between these totals and those given earlier in this paragraph being due to the imports of products manufactured from iron and steel, namely, railway plant and rolling stock, machinery and millwork, cutlery and hardware. The figures for iron and steel imports show that there is room in the country for a large iron-manufacturing industry bringing in its train the manufacture of machinery, railway plant, etc. A beginning has undoubtedly been made in this direction, but the effect will not be seen in the figures for imports until the next quinquennial period.

Jadeite.

When the last Quinquennial Review was issued in 1908, jadeite stood ninth in order of value in the Indian mineral production. Although the average annual value increased during the period under review, this mineral now stands only eleventh on the list; this can only be

viewed with satisfaction since it is due to the rise of new industries connected with minerals valuable in the arts, such as lead and wolfram; whilst it is not improbable that during the next quinquennial period jadeite will be found to have given place also to iron and tin.

Lead and silver.

It is satisfactory to be able to add lead and silver to the list of metals now being won in the Indian Empire. The operations of the Burma Mines Company, Limited, which began in 1908, were continued throughout the period under review and have resulted in the production, partly from old slags and partly from newly won ore, of 45,500 tons of lead and nearly 400,000 ounces of silver during the five years 1909-13, giving an annual average of 9,100 tons of lead and 80,000 ozs. of silver with a joint annual value of £135,793. During the same period the annual average imports of lead have been 7,057 tons and exports 7,614 tons. The net annual average import of silver, however, was very much higher than the local production, and amounted to over 62 million ounces, valued at over 7 million pounds.

Magnesite.

During the previous quinquennial period the production of magnesite from the 'Chalk Hills' near Salem showed the violent fluctuations of an industry not yet firmly established; those fluctuations continued till 1909 when the production fell from 7,534 tons in 1908 to 737 tons. Since then the industry has been an expanding one with a production of 14,086 tons in 1913 and an annual average for 1909-13 of 7,775 tons valued at £2,278, against an average of 2,586 tons valued at £689 during the previous period. The product is nearly all exported after calcination on the spot, the average annual quantity of lightly calcined magnesite produced during 1909-13 being 2,157 tons valued at £7,191. The Tata Iron and Steel Company has commenced to extract magnesite in the Mysore district of Mysore for lining their steel furnaces at Sakchi.

Manganese.

During the period covered by the two previous reviews the Indian manganese-ore industry showed the phenomenal expansion characteristic of youth; the initial production of 674 tons in 1892 had expanded to a maximum of 902,291 tons in 1907, decreasing with a fall of price to 674,315 tons in 1908, when, owing to a much larger decrease in the Russian output, India assumed the first place amongst the

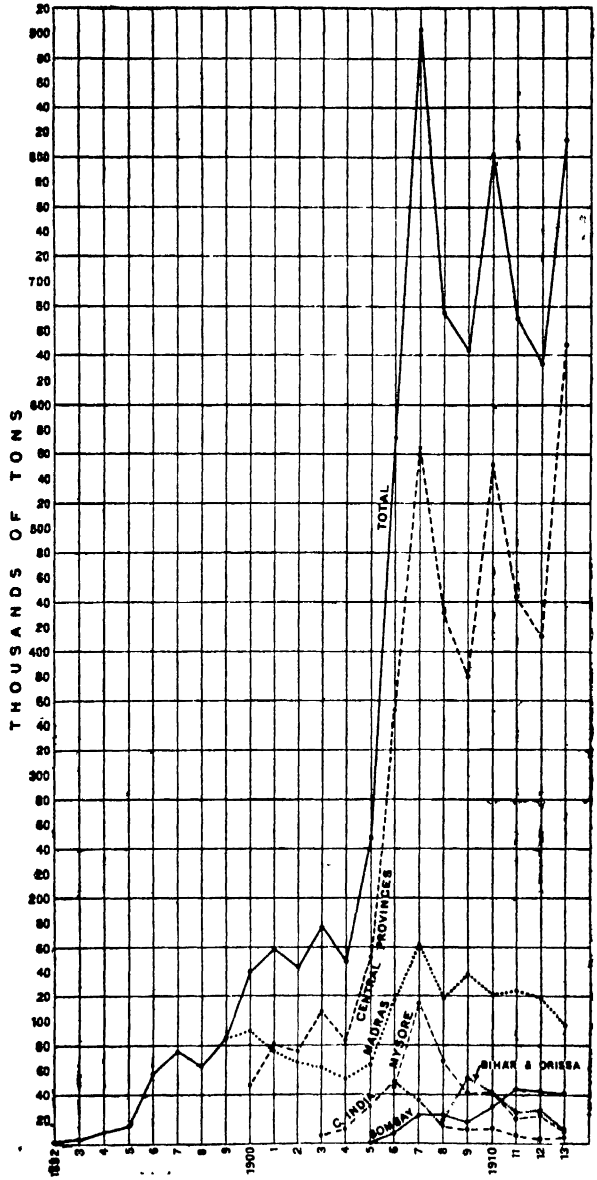


FIG. 5.—*Production of Manganese-ore since the commencement in 1892.*

world's producers of manganese-ore (see fig. 13, page 142). The record for the present period has been that of a relatively stable industry that has found its level in the world, the annual fluctuations in output being relatively small and due to changes in market price and rates of freight, and to political events, the gradual development of some deposits and exhaustion of others, whilst the period of discovery of new and valuable deposits of manganese-ore seems to have passed. During the five years 1909-13 the annual production of manganese-ore varied between 633,080 tons in 1912 and 815,047 tons in 1913, with an annual average of 712,797 tons, the average annual figures for the two previous quinquennia being 509,143 tons in 1904-08 and 133,083 tons in 1899-1903.

Reliable figures for the Russian manganese-ore production are difficult to obtain and always belated, but judging from the figures for the years 1909-13 given in the *Mineral Industry* for 1913,[1] India maintained during 1909 to 1911 its position as premier producer first gained in 1908, but yielded this place to Russia in 1912 and 1913. It is probable that with a proper organisation of its manganese-ore industry Russia could maintain this position, but conditions remaining as they are it is likely that the first place will pass alternately to India and Russia according to variations in economic and political conditions. During the five years 1908 to 1912,[2] the Indian and Russian productions constituted respectively 43·8 per cent. and 37·2 per cent. of the world's output of manganese-ore, which averaged 1,586,414 metric tons annually.

The average annual value of the ore produced in India during the years 1904-08 was £767,319. This has increased to £822,876 for the period 1909-13, the maximum value being £1,276,465 in 1913. Taking the average values for the period, manganese-ore has fallen from third to fourth position amongst the minerals produced in India, being exceeded by coal, gold and petroleum.

From fig. 5 it is seen that the output of the Central Provinces and Bombay has increased during the period 1909-13, whilst that of Madras, Mysore and Central India has fallen off. Gangpur in Bihar and Orissa first became a producer in 1908; the production from this State reached its zenith in 1909 and has since steadily declined. The net result is that the Central Provinces is contributing an increasing proportion of the total Indian production and has itself contributed 28 per cent. of the world's production during the five years 1908-12.

Mica.

The three principal contributors to the world's supply of mica are India, Canada, and the United States of America. During the quinquennial period 1894-1898 the total value of the mica produced in these three countries was £464,154, of which 68·1 per cent. was due to India; the total value of the mica produced by the same three countries from 1899 to 1903 was £709,785 and the Indian contribution fell to 60·1 per cent.; from 1904 to 1908 the total value of the mica produced amounted to £1,404,203 and the Indian con-

[1] The 1910, 1911 and 1912 figures relate to exports only, and are therefore incomplete as there is a certain internal consumption of manganese-ore in Russia.

[2] Figures for 1913 are not yet available for most countries.

tribution increased slightly, namely, to 61·8 per ceyt of the total. while for the period under review the figures are £1,713,580 and 65·1 per cent. respectively. India's share of the industry is therefore greater now than it has been for nearly twenty years.

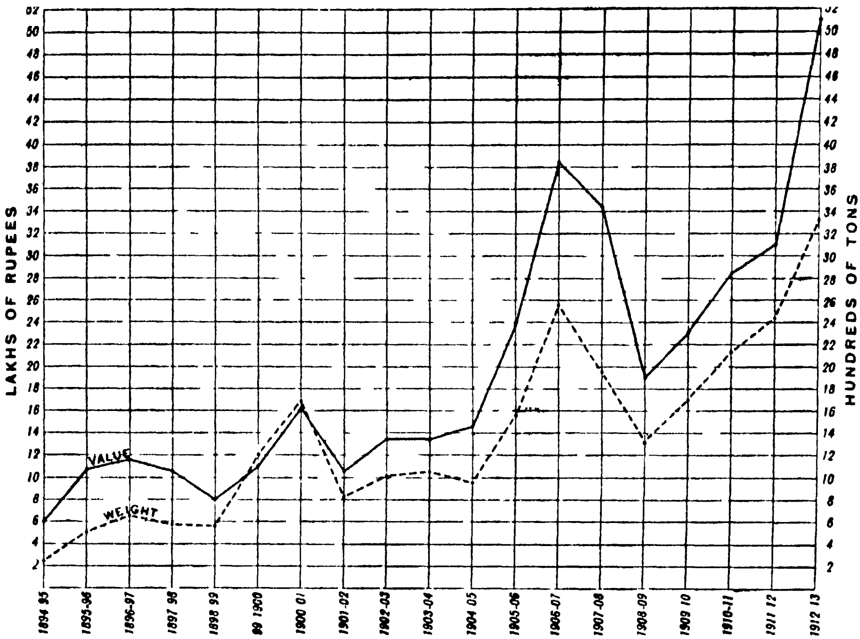


FIG. 6.—*Exports of Indian mica during the past 20 years.*

The average annual value of the mica produced in India during the four quinquennial periods has been:—

	£
1894-1898	63,203
1899-1903	85,370
1904-1908	173,511
1909-1913	239,130

The great increase in the last two periods is due to the invention of micanite, which is manufactured from scrap mica; the cheapness

of this product has led to the greatly extended use of mica for electrical purposes.

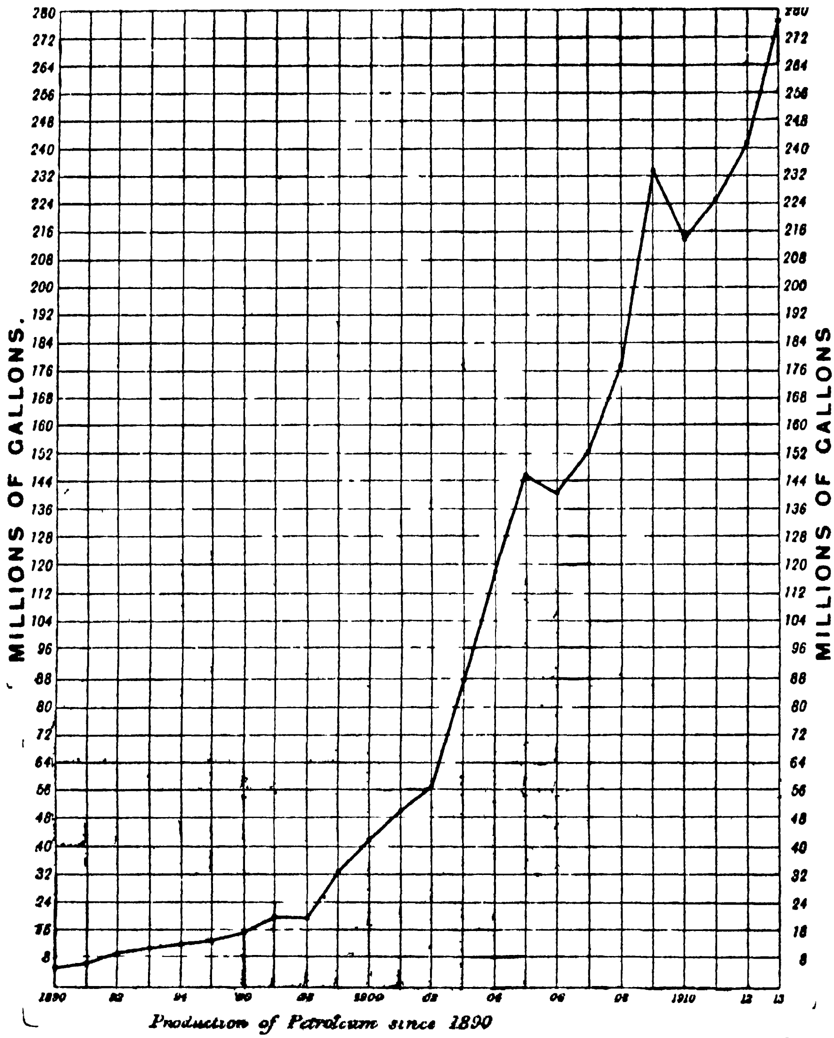


Fig. 7.

Fig. 6 shows the fluctuations in the total weight and total value of the mica exported during the past twenty years.

Monazite.

Amongst the Indian minerals, the production of which has been commenced during the period under review, is monazite. This is found in the sands on the sea-shore of Travancore, from which there was a production in 1913 valued at over £40,000.

Petroleum.

The production of petroleum has increased from 19 million gallons in 1897 to 277½ million gallons in 1913 (see fig. 7). The average annual value of petroleum produced has increased from £592,887 for the period of the previous review to £1,034,586 for the present period. During the refining of petroleum, paraffin wax, petrol, and other products are obtained, and there has been a great increase during the period in the export of paraffin wax, from 144,597 cwts. in 1909 to 272,226 cwts. in 1913.

Rubies, sapphire, and spinel.

Next to petroleum, rubies used to form the chief source of revenue amongst the mineral products of Burma. In recent years however this industry has been outstripped by those of lead and tungsten, and it is probable that before long it will also be of less importance in Burma than the tin industry. The Burma Ruby Mines, Limited, paid formerly an annual rent of two lakhs of rupees (£13,333) and a royalty of 30 per cent. of their annual net profits. These terms have recently been modified owing to the continued depression in the industry, and the Company has been able to open up new ground at Kathé, eight miles from Mogok; it is hoped that this may place the industry on a better basis. The average value of the annual output of rubies, sapphires and spinels for the period under review was only £63,272, as compared with £84,406 during the period previously reviewed.

Salt.

The amount of salt produced annually during the period 1909-13 has amounted on an average to nearly 1½ million tons, a considerable increase over the amount produced in the preceding quinquennial period, the average of which was under 1,200,000 tons per annum. The annual average imports also increased from 484,940 tons in 1904-08 to 552,299 tons in 1909-13. The greater absorption of salt is no doubt attributable in part to increase of population and reduction of the salt tax, but good agricultural seasons and the steadily increasing prosperity of the country constitute probably a not unimportant factor.

Saltpetre.

The production of saltpetre is evidently understated, being considerably below the quantities returned as exports. The average annual exports for the five years amounted to 331,531 cwt. as compared with 358,989 cwt. during the period previously reviewed. As, however, the value per cwt. was slightly greater, the average annual value during the period of the present review was £252,634 as compared with £265,135 during the previous period. Of this amount 27·2 per cent. by weight went to the United States, 19·2 per cent. to the United Kingdom, and 23·7 per cent. to Hongkong. 58 per cent. of the saltpetre was manufactured in Bihar and 31 per cent. in the United Provinces; over 98 per cent. of the total left India through the port of Calcutta. The trans-frontier imports of saltpetre from Nepal averaged 9,172 cwt. annually as compared with 4,156 cwt. in the previous period.

Tin.

During the period under review the tin-mining industry in Burma made very considerable strides; the value of the output of block tin and tin-ore rose from £9,645 in 1909 to £46,401 in 1913, the annual average for the five years being £30,100 as against £10,992 in the previous quinquennial period. Much of the work was carried out on primitive native principles, but dredging machinery has recently been introduced and its employment will, it is hoped, prove a success. The areas being worked lie chiefly in the districts of Mergui and Tavoy, but a certain amount of material has been won in Bawlake State, Southern Shan States, where the Mawchi Tin and Wolfram Mines Company, Limited, an offshoot from the Southern Shan States Syndicate, has been engaged in developing the tin and wolfram deposits of Mawchi.

Tungsten.

A marked feature of the development of the mineral industries of India during the period 1909-13 is the rapid rise of the wolfram industry in the districts of Mergui and Tavoy in Lower Burma. Although there was an output of 7 tons from Mergui in 1909, the industry dates practically from the following year, 1910, when the output was 396 tons; it then rose rapidly to nearly 1,700 tons, valued at £127,762 in 1913. All this material was won under prospecting licenses, the methods employed being both primitive and wasteful. Attempts, however, are being made to put the industry on a sounder

basis and to guard against the damage resulting to the wolfram lodes from the operations of the mere company-promoter, a class which has become undesirably conspicuous in Burma in recent years and has done much to discredit, and so to retard the development of, the mineral resources of that province.

III.—DETAILED ACCOUNT OF THE MINERALS OF GROUP I.

Chromite.

Chromite is known to occur with serpentine and other rocks of the peridotite family in the "Chalk Hills" near Salem, in the Andamans, in Baluchistan, in Mysore, and in Singhbhum. Attempts were made many years ago to work the deposits near Salem, but were not persisted in. No attempt has been made to work this mineral in the Andamans. Work was commenced on the Baluchistan deposits in 1903, the output for the first year of work being returned as 284 tons. The production from the two producing districts—Quetta-Pishin and Zhob—is shown in table 5, from which it will

Baluchistan.

TABLE 5.—*Production of Chromite during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		*Average.*	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Baluchistan .	4,325	*5,767*	1,737	*2,315*	3,804	*5,072*	2,890	*3,849*	3,414	*1,162*	3,234	*3,633*
Mysore . .	4,925	*1,970*	*Nil*	..	*Nil*	..	*Nil*	..	1,414	*821*	1,268	*558*
Bihar and Orissa (Singhbhum).	..	..	..	..	..	..	..	..	848	*452*	170	*91*
TOTAL .	9,250	*7,737*	1,737	*2,315*	3,804	*5,072*	2,890	*3,849*	5,676	*2,435*	4,671	*4,282*

be seen that the total production for the period under review is 16,170 tons, corresponding to an average annual output of 3,234 tons. The chromite is exported from Karachi, and is of high grade, occurring as veins and irregularly segregated masses in serpentines that accompany great basic intrusions of upper Cretaceous age.[1]

[1] E. Vredenburg, *General Report, Geol. Surv. Ind.*, for 1902-03, p. 9.

Mysore.

In Mysore State chromite has been found in the districts of Mysore, Hassan, and Shimoga. It has been worked in the first two districts only, the production for 1907, the first year of work, being 11,029 tons. As only 201 tons of this total was exported from Mormugao—the port of shipment for most of the minerals of Mysore—large stocks have accumulated, and the production fell to nothing during the years 1910-12, there being a slight revival in 1913 indicated by an output of 1,414 tons of an estimated value of £821.

Shimoga district.

Chromite seems to have been first found in Mysore by the late Mr. H. K. Slater, who found a rock showing grains of chromite in a talcose matrix near Harenhalli in the Shimoga district.[1] Even the richest specimens did not indicate more than 35 to 40 per cent. of Cr_2O_3.

Mysore district.

The most important of the Mysore chromite deposits is situated near the village of Kadakola in the Mysore district (first taken up on license in 1906). The 'country' consists of gneiss with occasional patches of hornblende-schist. It is cut by a couple of ultra-basic dykes of the dunite series, one of which has been completely altered to serpentine for a length of about two miles. The chromite occurs for the most part as a narrow vein, averaging, probably, not more than 9 to 12 inches in thickness. But in one place it forms a large lens. Several thousand tons of chromite have already been quarried in this area. The ore is of fairly good quality, often yielding on analysis from 50 to 52 per cent. of Cr_2O_3; but a considerable proportion of it is probably of lower grade.[2]

Hassan district.

Chromite was found in the Hassan district in 1906 over a length of about 20 miles, in some altered ultra-basic rocks—tremolite and enstatite largely altered to talc and serpentine—located in a belt of hornblendic schists. The ore consists, for the most part, of small grains of chromite embedded in a talcose matrix. Some of the better portions of the rock probably contain 30 to 40 per cent. of Cr_2O_3.

Operations, however, have been largely confined to Mr. J. Burr's block at Kadakola, the output from which was 4,727 tons in 1909, of which only 3,320 tons were sold the same year. Owing to low prices, mining ceased for the next three years, but there

[1] *Rec. Mysore Geol. Dept.*, II, p. 129.
[2] Report, Chief Inspector of Mines, Mysore, for 1906-07, p. 36.

were signs of a revival in 1912, eight prospecting licenses being taken out in Mysore district and one in Hassan district; in 1913, as stated above, mining was resumed.[1]

Singhbhum.

In 1907 a specimen found by Mr. R. Saubolle, prospecting on behalf of Messrs. Martin and Co. of Calcutta, near the Suru pass on the road from Chaibasa to Sonua, Bengal-Nagpur Railway, in the Singhbhum district, Bihar and Orissa, proved on examination in the Geological Survey Office to be chromite. The ore occurs as bed-like veins and as scattered granules in serpentine. A sample taken from a total of about 10 tons of ore extracted from twelve prospecting pits showed 50·05 per cent. of Cr_2O_3, and a picked specimen 53·19 per cent. Prospecting operations on this and two other occurrences in the immediate vicinity did not at the time disclose any large bodies of ore, but only irregular veins. In 1913 there was an output from Singhbhum of 848 tons valued at £452; this was raised by Messrs. Schröder, Smidt & Co. in the Saitba block of the Kolhan Government estate.

Coal.

Progress in output.

Since the year 1882 the expansion in the coal mining industry has been uninterrupted, and during the past ten years the production has been doubled. In the quinquennial period under review, the total production rose from 11,870,064 tons in 1909 to 16,208,009 tons in 1913, an increase of 36·5 per cent. The annual figures for production and value during the quinquennial period are shown in table 6.

TABLE 6.—*Production and Value of Coal during the years 1909 to 1913.*

YEAR.	Quantity.	Total value at the mines.		*Average value per ton at the mines.*	
	Tons.	Rs.	£	Rs. A.	*s. d.*
1909 . . .	11,870,064	4,16,97,985	2,779,865	3 8	*4 8*
1910 . . .	12,047,413	3,68,33,162	2,455,544	3 1	*4 1*
1911 . . .	12,715,534	3,75,39,234	2,502,616	2 15	*3 11*
1912 . . .	14,706,339	4,96,55,469	3,310,365	3 6	*4 6*
1913 . . .	16,208,009	5,69,72,055	3,798,137	3 8	*4 8*

[1] Annual reports of the Chief Inspector of Mines, Mysore.

Prices.

It should be remembered that the values stated are, in reality, the prices paid for coal at the pit's mouth, and these are necessarily dependent upon the relation between local supply and demand, not indicative of the actual value of the fuel. Bengal coal, which is all-round the best quality worked in India, is returned as having a lower value than the coal worked in other provinces, where higher prices can be safely demanded by the miner.

The average cost of coal to the consumer in India is low compared to that of most of the principal coal-producing countries of the world. The following table shows the declared pit-mouth value in some other countries during the five years 1908 to 1912 :—

Countries.	Per ton.	Countries.	Per ton.
	s. *d.*		*s.* *d.*
United Kingdom	8 5¾	France	12 7
United States	5 10¾	Australia	7 6
Germany	10 4¼	Japan	7 8¾

Comparison of India with Australia, Canada and South Africa.

As will be seen from table 7, India still maintains her lead in output over all other British dependencies. Canada was overtaken in 1896 and Australia in 1902. The rate of increase of output in India is considerably greater than in Australia, which fell further behind in practically every year between 1908 and 1912, and was out-distanced by Canada for the first time by any large amount in 1910. It is interesting to note also that India's share of the total output of the British Empire has risen from 3·65 per cent. during the period 1903-07 to 4·6 per cent. in 1908-12. In 1912 the production of this country exceeded that of Australia by over 3 million tons and of Canada by over 1¾ million. The cause of this is doubtless to be found in the greatly increased industrial activity of India during the period under review, leading not only to an increased consumption of coal in the producing industries, such as jute and cotton, but also to an increased consumption of coal on the railways engaged in the carriage of the products of India's industrial and agricultural activity; and as but

a small proportion of the Indian coal is exported, this largely increased production may be regarded as an index of the increase in prosperity of India during the period considered.

TABLE 7.—*Production of Coal in the four largest British Dependencies.*

COUNTRIES.	1908. Metric Tons.	*Per cent. of British output.*	1909. Metric Tons.	*Per cent. of British output.*	1910. Metric Tons.	*Per cent. of British output.*	1911. Metric Tons.	*Per cent. of British output.*	1912. Metric Tons.	*Per cent. of British output.*
India .	12,974,558	*4·23*	12,060,550	*3·94*	12,240,744	*3·92*	12,919,587	*4·04*	14,942,340	*4·60*
Australia .	10,357,218	*3·38*	8,316,452	*2·71*	9,915,602	*3·18*	10,719,430	*3·35*	11,918,018	*3·78*
Canada .	9,875,902	*3·22*	9,526,784	*3·11*	11,710,993	*3·75*	10,272,411	*3·21*	13,165,826	*4·18*
South Africa	4,943,332	*1·61*	5,690,015	*1·86*	6,508,383	*2·08*	6,890,022	*2·15*	7,363,693	*2·34*
TOTAL for British Empire.	**306,015,146**	..	**305,759,126**	..	**311,613,510**	..	**319,442,709**	..	**324,482,127**	..

Comparison of India with Japan.

A serious competitor with India for the supply of coal to Ceylon, the Straits Settlements, Sumatra, and Java, is Japan; whilst, in the Pacific, Indian coal has, as a rule, little chance of competing on successful terms with the Japanese coal, owing mainly to questions of freight. Japan, also, is developing rapidly industrially, and therefore, in these circumstances, it is interesting to compare the production of coal in the two countries. A reference to table 8 will show that, in 1885, the Indian and Japanese productions were practically identical, *viz.*, a little under 1,300,000 tons. From thence onward the production of Japan increased first at a slightly greater, and latterly at a considerably greater, rate than that of India. Thus in 1900, the Indian production was a little over 6 million tons, and the Japanese over 7 millions; in 1905, the Indian output was 8·4 million tons, and the Japanese 3 millions more. By 1908, the Indian output had increased to nearly 12·8 million tons, with the Japanese over 2 millions more, while in 1913 the Indian was a little over 16 millions and the Japanese nearly 21 millions. The

coal exports of Japan, which by its position commands the ports of China, have risen to a much larger figure than those of India. The consequence is that the quantity of coal retained for consumption in Japan is not much greater than the amount consumed in India, although the ratio in favour of Japan is gradually increasing as will be seen by a comparison of the last column of table 8 with the figures given in table 9. In making this comparison it must also be remembered that a given consumption of coal in Japan registers a much greater proportional industrial activity than does the same consumption of India, on account of the much smaller population of the former country.

TABLE 8.—*Comparison of the Indian and Japanese Coal Statistics.*

YEAR.	PRODUCTION.		IMPORTS.		EXPORTS.		Quantity retained for consumption in Japan.
	India.	Japan.	India.	Japan.	India.	Japan.	
1885 .	1,294,221	1,294,000	790,930	12,876	750	191,802	1,115,074
1890 .	2,168,521	2,566,551	784,664	12,301	26,649	853,720	1,725,132
1895 .	3,540,019	4,733,861	761,996	68,931	81,126	1,376,068	3,426,724
1900 .	6,118,692	7,369,068	135,649	108,593	490,491	2,402,785	5,074,876
1905 .	8,417,739	11,407,799	197,784	329,495	783,051	2,507,527	9,229,767
1909 .	11,870,064	14,732,970	490,421	129,858	563,940	2,798,563	12,064,265
1910 .	12,047,413	15,429,303	315,996	171,805	988,375	2,770,788	12,830,320
1911 .	12,715,534	17,251,456	318,669	256,565	862,384	3,250,816	14,257,205
1912 .	14,706,339	19,324,116	560,791	303,374	898,996	3,412,136	16,215,354
1913 .	16,208,009	20,973,584	644,934	567,502	759,210	3,808,394	17,732,492

Relation of consumption to production.

The market for Indian coal must be limited to (1) the home industries, and (2) the Indian Ocean ports, where the manufacturing industries requiring coal are comparatively few, and where India is not the sole supplier of fuel. Tables 9 and 12 show that, during the five years under review, India consumed on an average 93·9 per cent. of the coal produced in the country,

and, in addition, imported annually on an average 477,824 tons of foreign coal. This compares with an average consumption during the previous period of 92·6 per cent. of the coal produced in the country, in addition to an annual import of 256,821 tons of foreign

The actual annual consumption since 1908 has been, on the average, 13,235,788 tons, whilst the production during the same period has averaged 13,509,472 tons. As the consumption and production are so nearly alike, it is evident that the great expansion that has taken place in the Indian coal trade must be due, as already noted, to industrial developments in India itself. That it has little to do with increased facilities of transport and of consequent access to new markets is shown by a reference to table 12, from which it will be seen that the increase in the Indian exports has been very small, the average annual exports for the five years 1909-13 being only 814,475 tons as compared with 741,307 tons for the previous five years, 1904-08.

TABLE 9.—*Relation of Consumption to Production.* (*a*)

YEAR.	Total consumption of coal in India.	CONSUMPTION OF INDIAN COAL IN INDIA.	
		Quantity.	*Percentage of Indian production.*
	Tons.	Tons.	
1909	11,838,789	11,304,738	*95·2*
1910	11,397,824	11,057,235	*91·8*
1911	12,199,528	11,851,968	*93·2*
1912	14,420,672	13,806,055	*93·9*
1913	16,322,126	15,447,185	*95·3*
Average	*13,235,788*	*12,693,436*	*93·9*

(*a*) The consumption of coal is assumed to be production *plus* imports *minus* exports. In the imports and exports a ton of coke is taken to be equivalent to 2 tons of coal. The imports include Government stores.

Consumption of coal on Indian railways.

The quantity of coal consumed on the railways in India has steadily increased during the past quinquennial period as in the previous period reviewed. In 1899 the quantity of Indian coal consumed amounted to 1,557,000 tons, in 1908 it rose to 3,604,094, while during the period now under review the average annual consumption amounted to 4,195,052 tons. Yet the relation between the railway consumption of coal and that of the various industrial enterprises in the country keeps a fairly constant ratio. During the two previous quinquennial periods the Indian coal consumed on the railways was on an average 29·7 per cent. of the total production, while during the past five years the average percentage has been 31·1. Foreign coal was rapidly displaced by the Indian product after 1888, when it amounted to 31 per cent. of the total. Since 1900 the Indian collieries have supplied about 98 per cent. or more of the total railway requirements, and the amount of foreign material now taken is due to local and chance variations in ocean freights.

TABLE 10.—*Coal consumed on Indian Railways during the years 1909 to 1913.*

YEAR.	INDIAN COAL.			FOREIGN COAL.		**Total consumption.**
	Quantity.	*Per cent. of Total.*	Per cent. of Indian output.	Quantity.	*Per cent. of Total.*	
	Tons.			Tons.		**Tons.**
1909 . . .	3,657,896	*97·7*	30·8	84,559	*2·3*	**3,742,455**
1910 . . .	3,801,248	*98·6*	31·5	52,147	*1·4*	**3,853,395**
1911 . . .	4,223,020	*99·2*	33·2	32,132	*·8*	**4,255,152**
1912 . . .	4,590,618	*97·5*	31·2	118,582	*2·5*	**4,709,200**
1913 (*a*). . .	4,702,479	*94·1*	29·0	298,582	*5·9*	**5,001,061**
Average .	*4,195,052*	..	*31·1*	*117,200*	..	*4,312,253*

(*a*) Relates to the official year 1913-14.

Earnings from transport of coal.

The transport of coal forms an important item in the earnings of the Railway Companies, especially the East Indian and Bengal-Nagpur systems which serve the Raniganj, Jherria, Giridih, and Daltonganj fields. The traffic in coal for all Indian railways is shown in table 11. This table excludes coal carried by railways for their own consumption.

TABLE 11.—*Coal carried for the Public or Foreign Railways during the years 1909 to 1913.*

—	Coal carried on Indian Railways.	Earning of Railways from coal traffic.
	Millions of Tons.	£, Millions.
1909	12·15	2·20
1910	13·90	2·56
1911	14·51	2·75
1912	16·55	3·24
1913	17·16	3·31

Imports and exports.

Table 12 shows the relation between the imports of foreign coal and the exports of Indian coal during the past ten years. It will be seen that there has been a slight rise in the total imports, with a smaller increase in the exports; the average amounts imported and exported annually during the period 1909-13 being 466,162 tons and 814,475 tons respectively, as compared with 272,987 tons and 741,307 tons for the period 1904-08. The most striking feature in these figures is the marked rise in imports during the two last years of the period. From table 13, it will be seen that much of this increase came from Africa (Natal and Portuguese East Africa); this is interesting as indicating a distinct tendency to the capture of part of the Indian market. It is, however, probably merely a question of fluctuation of freight, in which case the increase or otherwise of imports of African coal will be determined by extraneous circumstances which may be largely independent of the trade in that commodity.

TABLE 12.—*Imports and Exports of Coal during the years 1904 to 1913.*

YEAR.	Imports.	Exports.
1904	253,874	**602,810**
1905	197,784	**783,033**
1906	226,365	**1,002,951**
1907	301,588	**658,145**
1908	385,323	**659,596**
1909	490,421	**563,940**
1910	315,996	**988,366**
1911	318,669	**862,177**
1912	560,791	**898,739**
1913	644,934	**759,155**
Average	*369,574*	**777,891**

TABLE 13.—*Origin of foreign coal imported into British India.*

YEAR.	From United Kingdom.	From Australia.	From Natal.	From Japan.	From other countries.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	**Tons.**
1909	311,213	54,792	91,907	11,413	21,096	**490,421**
1910	261,245	28,040	18,224	6,654	1,833	**315,996**
1911	245,043	35,703	15,086	6,975	15,862	**318,669**
1912	145,097	92,087	96,076	97,289	130,242	**560,791**
1913	185,034	51,344	136,730	97,208	174,618	**644,934**
Average	*229,526*	*52,393*	*71,605*	*43,908*	*68,730*	*466,162*

Exports.

The distribution of exported Indian coal is shown in table 14, from which it will be seen that Ceylon and the Straits remained as before the principal customers. During the previous period reviewed Ceylon took on an average 379,810 tons of Indian coal a year, against an average of 466,965 tons in the quinquennial period just completed. At the same time the quantities shipped to the Straits Settlements fell from an average of 200,795 tons in 1904-08 to an annual average of 187,525 tons in 1909-13. The average amount annually exported to Sumatra has also increased considerably, from about 64,000 tons to over 102,000 tons. On the other hand there have been no exports to Hongkong or to British East Africa.

TABLE 14.—*Exports of Indian coal.*

——	1909.	1910.	1911.	1912.	1913.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Aden . .	3,460	7,383	11,667	12,577	5,336	*8,084*
Mauritius .	..	4,905	..	5,320	1,890	*2,423*
Ceylon . .	313,385	522,019	494,063	579,151	426,206	*466,965*
Java . .	4,718	20,055	5,206	625	..	*6,121*
Straits Settlements.	128,768	236,933	225,459	149,031	197,433	*187,525*
Sumatra . .	79,394	100,234	109,383	119,427	102,759	*102,239*
Other countries	34,215	96,837	16,399	32,608	25,531	*41,118*
TOTAL, Exports	**563,940**	**988,366**	**862,177**	**898,739**	**759,155**	*814,475*
VALUE .	£ 338,394	£ 572,798	£ 484,270	£ 601,817	£ 496,438	£ *198,743*

Possible expansion of the export trade.

The two tables 15 and 16 show the extent of the two chief markets, for which India has to compete with Australia, Japan, and Natal. The British coal taken in Ceylon and the Straits Settlements is not all in competition with Indian coal, for some of the mail steamers must accept the high quality of steaming fuel from England in spite of the comparatively low prices of material obtainable from India and the Pacific. The variations in the share which India takes in these markets is of little value as an index to the growth of the industry; the collieries have often been barely able to meet the domestic demand, and Indian consumers complain no

less than outside customers of the quantities of low-grade fuel forced on them during a boom.

One cannot say that there is any prospect of India sending much coal to Pacific ports; although the principal competitors at present are Japan and Australia, and these two countries will find domestic markets for their coal in their own industrial developments. China, however, is known to possess large deposits, which will remain locked up until more perfect transport facilities are provided from the fields to the coast.

TABLE 15.—*Foreign Coal Imports of Ceylon for the years 1909 to 1913.*

ORIGIN OF THE COAL.	1909.	1910.	1911.	1912.	1913.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom	260,852	339,623	260,289	278,466	234,234	*274,693*
British India .	270,578	448,583	395,878	555,628	364,020	*406,937*
Japan . .	16,644	7,671	520	32,017	94,317	*30,234*
Other countries	4,667	5,502	8,360	19,550	51,958	*18,007*
TOTAL, Imports	**552,741**	**801,379**	**665,047**	**885,661**	**744,529**	*729,871*

TABLE 16.—*Imports of Coal into the Straits Settlements for the years 1909 to 1913.*

ORIGIN OF THE COAL.	1909.	1910.	1911.	1912.	1913.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom.	53,522	13,264	27,402	21,000	22,000	*27,438*
British India .	125,340	239,282	230,534	143,000	195,000	*186,631*
Australia. .	137,918	107,259	136,851	120,000	162,000	*132,806*
Japan . .	241,203	312,165	349,911	484,000	499,000	*377,256*
Other countries	119,574	86,645	67,493	93,000	203,000	*113,942*
TOTAL, Imports	**677,557**	**758,615**	**812,191**	**861,000**	**1,081,000**	*838,073*

Calcutta exports.

During the period under review the average quantity of coal shipped annually from Calcutta to other Indian ports remained almost exactly the same as in the previous quinquennial period, *viz.*, 2·141 million tons as against 2·136 millions. For the distribution of this coal see table 17. Karachi, Bombay, and Rangoon remain the chief

customers, but the amounts sent to the two latter would probably have been much higher than they are had it not been for the successful competition of bunker coal from South and East Africa.

TABLE 17.—*Distribution of Bengal Coal*[1] *from Calcutta to Indian Ports during 1909 to 1913.*

PORTS.	1909.	1910.	1911.	1912.	1913.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Akyab	9,612	11,340	10,467	9,646	9,405	*10,094*
Bassein	9,534	5,344	14,476	10,785	11,555	*10,339*
Bhownagar	—	13,019	12,756	22,470	—	*9,649*
Bombay	844,336	1,016,198	935,678	902,422	916,103	*922,947*
Chandbali	765	767	696	520	657	*681*
Chittagong	28,714	15,223	25,728	24,123	25,080	*23,774*
Cocanada	500	—	—	—	—	*100*
Cuddalore	37,550	43,780	49,217	43,019	81,861	*51,085*
Karachi	449,612	417,034	256,907	351,053	351,285	*365,178*
Mandapam	28,260	44,748	30,115	33,556	37,359	*34,808*
Madras	181,965	123,748	104,858	180,619	176,156	*153,469*
Mormugao	68,870	74,666	63,791	72,730	61,609	*68,333*
Moulmein	3,615	3,859	5,431	9,356	4,959	*5,444*
Negapatam	29,889	41,635	34,510	38,526	40,468	*37,006*
Pondicherry	13,227	9,930	11,700	9,636	1,509	*9,200*
Port Blair	4,350	5,390	4,920	2,260	5,000	*4,384*
Rangoon	322,438	378,581	351,629	395,786	450,020	*379,691*
Tuticorin	2,350	13,438	22,679	27,486	33,533	*19,897*
Other Ports	20,012	21,179	39,514	40,665	54,575	*35,189*
TOTAL	**2,055,599**	**2,239,879**	**1,975,072**	**2,174,658**	**2,261,134**	*2,141,268*

[1] Owing to the recent re-arrangement of provincial boundaries much of the fields formerly known as the 'Bengal coalfields' are now in the province of Bihar and Orissa. The coal, however, is so widely known as 'Bengal coal' that it would be pedantic to change its appellation.

Table 18 shows the provincial production for the years 1909 to 1913. It will be seen that Bengal and Bihar, which yield Gondwana coal only,

Provincial production.

TABLE 18.—*Output of Indian Coal by Provinces for the years 1909 to 1913.*

PROVINCE.	1909.	1910.	1911.	1912.	1913.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Assam . .	305,563	297,236	294,893	297,160	270,862	1,465,714
Baluchistan .	52,449	52,614	45,707	54,386	52,932	258,088
Bengal . .	3,526,238	3,737,322	3,858,574	4,306,129	4,649,985	20,078,248
Bihar and Orissa .	7,134,573	7,041,208	7,610,330	9,126,385	10,227,557	41,140,053
Central India .	121,496	130,400	143,558	149,921	148,978	694,353
Central Provinces	238,100	220,437	211,616	233,996	235,651	1,139,800
Hyderabad .	442,892	506,173	505,380	481,652	552,133	2,488,230
North-West Frontier Province.	96	90	140	50	90	466
Punjab . .	37,208	49,189	30,575	38,409	51,040	206,421
Rajputana (Bikaner).	11,419	12,744	14,761	18,251	18,781	75,986
TOTAL .	*11,870,064	12,047,413	12,715,534	14,706,339	16,208,009	6,747,359

increased their output from 11½ million tons in 1909 to nearly 15 million tons in 1913. Among the other provinces, Baluchistan shows no pronounced change since 1903. In the following year the production reached nearly 50,000 tons, and then fell back to between 41,000 and 45,000 tons, but rose in the period under review to an annual average of nearly 52,000 tons. The production recorded for Central India is entirely that due to the Umaria collieries, where there has been a slight falling-off during the past five years. In the Central Provinces, where the production varied for many years between 140,000 and 190,000 tons, there was a sudden drop in 1906, due to the closing down of the Warora colliery, only partially compensated by increased activity in the Pench Valley area and at Mohpani. The rapid rise during the years 1907 and 1908 was

due largely to increased production in the Pench Valley field, but partly also to the development of new collieries at Ballarpur in the Chanda district. During the past five years 1909-13 the production has been fairly steady, between 211,000 and 240,000 tons annually. The production of Assam is nearly all due to the coal mines in the neighbourhood of Margherita in the Lakhimpur district of North-East Assam. The production in this area reached its maximum in 1909, but is limited mainly by the difficulties due to working inclines in thick seams liable to spontaneous combustion. The production recorded for Hyderabad is due to the mines at Singareni, which have maintained an average output of between 400,000 and 500,000 tons for the last fifteen years. There has been no noteworthy change in the production of the Punjab, where the only coal obtained is from the mines in the Tertiary rocks of the Salt Range area. The production recorded for Rajputana is that of the Palana colliery in the Bikanir State. The maximum production of this colliery occurred in 1904, when 45,000 tons were obtained. Since then there has been a noticeable decline in the output, the annual average of which fell from nearly 34,000 tons in the period 1904-08 to a little over 15,000 tons in 1909-13. The lowest figure, 11,450 tons, was reached in 1909, since when there has been a slight but steady improvement, the output for 1913 having been nearly 19,000 tons.

Geological Relations of Indian Coal.[1]

The Gondwana system.

The formation from which 97 per cent. of the coal supplies of India is obtained was named the *Gondwana* system by H. B. Medlicott in 1872.[2] It is[3] 'chiefly composed of sandstones and shales, which, except for some exposures along the East Coast, appear to have been entirely deposited in fresh water, and probably by rivers.'

The lowest division of the system is known as the *Talchir* series from its original discovery in the small State of this name in Orissa.[4]

[1] See also V. Ball and R. R. Simpson: The Coalfields of India, *Mem. Geol. Surv. Ind.*, XLI, pt. i, (1913).

[2] F. Stoliczka, *Rec. Geol. Surv. Ind.*, IX, p. 28, (1876); and *cf. Rec. Geol. Surv. Ind.*, XIV, p. ii, (1881).

[3] R. D. Oldham, Medlicott and Blanford, Manual, Geol. Ind., 2nd Ed., p. 149, (1893).

[4] T. Oldham, *Mem. Geol. Surv. Ind.*, I, p. 46, (1856).

The beds of this series are of small thickness; but they are known and, from their peculiar features, easily recognised in most of the coalfields. They include boulder-beds supposed to be due to glacial action, and are thus regarded as similar in origin, probably also corresponding in geological age to the Dwyka formation which lies at the base of the similar coal-bearing Karoo system in South Africa.

The only section of the Gondwana system which is important from the coal-producing point of view is that distinguished as the *Damuda* series,[1] from its development in the valley of the Damuda river. In the Raniganj and Jherria fields this series can be subdivided into three stages, of which that distinguished as the *Barakar* below and that known as the *Raniganj* stage above the *Ironstone shales* both include valuable coal-seams. The Raniganj stage produces the principal part of the supplies obtained from the Raniganj field; but seams in this stage of the Jherria field are generally thinner and poorer than those in the Barakar stage.

Age of the Lower Gondwana coal-measures.

The absence of marine formations throughout the lower division of the Gondwana system made it impossible at first to determine with any precision the geological age of the coal-measures with reference to the recognised standard stratigraphical scale of Europe. The geologists who first separated the Talchirs from the overlying strata of the Gondwanas regarded them on slender indirect evidence as probably not more recent than Permian in age.[2] On account of the affinities of the plant remains in the Lower Gondwanas, they were regarded as Triassic in age, while the Rajmahal beds in the Upper Gondwanas were considered to be Jurassic.[3] A reconsideration of the fossil evidence and comparison with similar beds associated with marine formations in Australia tended to confirm the earlier conclusions regarding the Palæozoic age of the Lower Gondwanas.[4] The recent discovery of typical Lower Gondwana plant remains embedded in marine formations in Kashmir, where they were deposited probably near the mouth of one of the great rivers flowing from Gondwanaland into the great ocean then covering the area now occupied by Central

[1] T. Oldham, *Journ. As. Soc. Bengal*, XXV, p. 253, (1856).
[2] W. T. and H. F. Blanford and W. Theobald, *Mem. Geol. Surv. Ind.*, I, p. 82, (1859).
[3] O. Feistmantel, *Rec. Geol. Surv. Ind.*, IX, p. 79, (1876).
[4] See recapitulation by W. T. Blanford, *Rec. Geol. Surv. Ind.*, IX, pp. 79—85, (1876).

Asia, confirms the conclusion regarding the Palæozoic age of the Lower Gondwanas: these Gondwana plants have been found in beds that are certainly not younger than Upper Carboniferous.[1] Thus, the Indian coal-measures are not much younger than, and may even be of the same age as, those of Europe.

Although there are coal-seams in the Jurassic rocks of Cutch and in the Cretaceous beds of Assam, all the coal being worked outside the Gondwana fields is of Tertiary age.

Eocene coal: Palana.

At Palana in the Bikanir State, Rajputana, a lignitic coal containing small nodules of resin lies immediately underneath Nummulitic limestones,[2] from which characteristic Lutetian (middle Eocene) fossils have been obtained.[3]

Tertiary coal in Assam.

Coal of the same age is being worked in the Punjab and Baluchistan, while some of that worked on a small scale in the Khasi and Jaintia Hills of Assam is also associated with Nummulitic rocks. The thick seams of the Lakhimpur district, which yield most of the coal now mined in Assam, belong to a series of beds whose age is not determinable by direct evidence, as they have not been found in contact with any fossiliferous marine formations. The same series yields the petroleum of the Digboi area, and because of this circumstance together with the fact that the overlying sandstones resemble the Pliocene Irrawaddy series overlying the Miocene oil-bearing strata in Upper Burma, there is a temptation naturally to regard the Lakhimpur coal and associated petroliferous beds as Miocene in age.

Some of the small coal basins on the Assam plateau are said to be of Cretaceous age, the coal in these basins being always characterised by containing lumps of fossil resin like those found in the Palana lignite.

Geological origin of the coal.

Table 19 shows the origin of the coal produced during the years 1909 to 1913. It will be noticed that the output from the Gondwana coalfields, which in the period 1904-08 averaged 95·85 per cent. of the total production, has gradually become a larger fraction of the total. In

[1] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXVI, p. 38, (1907).
[2] T. D. LaTouche, *Rec. Geol. Surv. Ind.*, XXX, pp. 122—125, (1897).
[3] E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVI, p. 314, (1907).

1909, 96·57 per cent. of the coal was obtained from the Gondwana fields, and 3·43 per cent. from Tertiary beds, while in 1913, 97·57 per cent. of the total belonged to the former category and only 2·43 per cent. was Tertiary coal.

TABLE 19.—*Origin of Indian Coal raised during the years 1909 to 1913.*

YEAR.	FROM GONDWANA STRATA.		FROM TERTIARY STRATA.		Total Production.
	Tons.	*Per cent. of Total.*	Tons.	*Per cent. of Total.*	Tons.
1909 . .	11,463,299	*96·57*	406,765	*3·43*	**11,870,064**
1910 . .	11,635,540	*96·58*	411,873	*3·42*	**12,047,413**
1911 . .	12,329,458	*96·96*	386,076	*3·04*	**12,715,534**
1912 . .	14,298,083	*97·23*	408,256	*2·77*	**14,706,339**
1913 . .	15,814,304	*97·57*	393,705	*2·43*	**16,208,009**
Average .	*13,108,137*	*97·03*	*401,335*	*2·97*	**13,509,472**

During the previous period reviewed, the contribution from the Gondwana coalfields rose from 95 to nearly 97 per cent. of the Indian total. During the past quinquennial period this percentage rose to 97·57, due to great activity in Bengal and Bihar, and especially to the rapid development of the Jherria coalfield. When the Review of Mineral Production was issued in 1903, the Raniganj field was still the leading field in India, and it maintained its lead up to the year 1905. In 1906, however, Jherria went ahead of Raniganj, and in subsequent years has steadily increased its lead, until it now produces more than half of the total production of India (see fig. 8, p. 47). The figures of production from the Gondwana coalfields are shown in table 20.

The Gondwana coalfields.

TABLE 20.—*Output of Gondwana Coalfields for the years 1909 to 1913.*

COALFIELD.	1909.		1910.		1911.		1912.		1913.	
	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total*
Bengal, Bihar and Orissa—										
Daltonganj . .	84,290	·71	84,996	·70	70,662	·55	71,917	0·49	85,345	·53
Giridih . . .	704,593	5·93	679,304	5·64	704.443	5·54	730,530	4·97	806,810	4·98
Jherria . . .	5,832,672	49·14	5,794,616	48·10	6,373,728	50·13	7,653,452	52·04	8,608,310	53·11
Rajmahal . .	1,900	·04	2,788	·05	1,978	·02	2,775	0·07	3,572	·04
Ramgarh-Bokaro .	2,544		3,390		468		8,258		3,319	
Raniganj. . .	4,034,812	33·99	4,212,606	34·98	4,311,956	33·91	4,944,268	33·62	5,327,248	32·87
Sambalpur (Hingir-Rampur).	..	..	830		5,669	·04	21,314	·14	42,805	·26
Darjeeling . .	..	..	..	..	..	..	..	..	133	..
Central India—										
Umaria . . .	121,496	1·02	130,400	1·08	143,558	1·13	149,921	1·02	148,978	·92
Central Provinces—										
Ballarpur . .	85,237	·72	93,276	·77	96,603	·76	86,417	0·59	80,959	·50
Pench Valley . .	92,196	·77	87,677	·73	63,030	·50	90,722	0·62	89,805	·55
Mohpani . .	60,667	·51	39,484	·33	51,983	·41	56,857	0·39	64,887	·40
Hyderabad—										
Singareni . .	442,892	3·74	506,173	4·20	505,380	3·97	481,652	3·28	552,133	3·41
TOTAL Gondwana beds	**11,463,299**	96·57	**11,635,540**	96·58	**12,329,458**	96·96	**14,298,083**	97·23	**15,814,304**	97·57

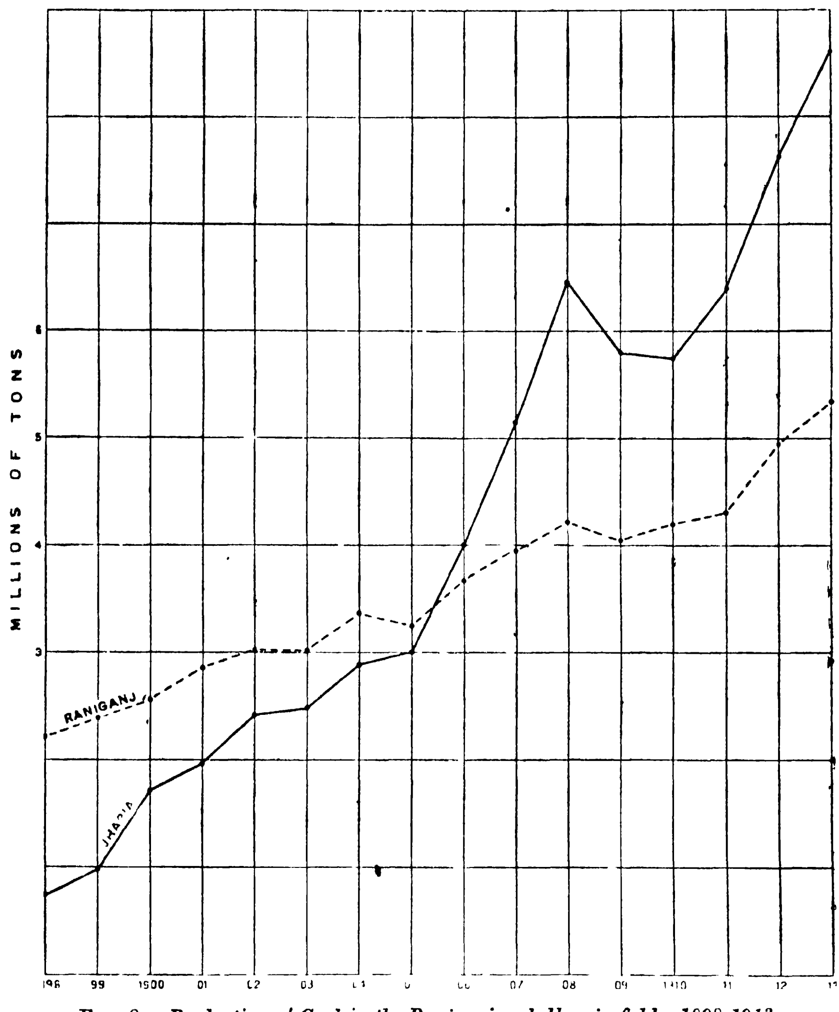


FIG. 8.—*Production of Coal in the Raniganj and Jherria fields, 1898-1913.*

The Gondwana coals have been preserved on the eastern part of the Peninsula by being faulted down into the Archæan basement complex; but either the faulting or the softness of the Gondwana rocks has determined the direction of the Damuda, Mahanadi, and Godavari valleys in which the principal fields are found. In the Central Provinces the Gondwana rocks form the Mahadeva or Mahadeo Hills, a portion of the Satpura

Distribution of the Gondwana fields.

hill-range, which stands up above the general peneplain of the Peninsula.

The fields which have been worked to any extent include the Raniganj and Jherria fields in the Damuda Valley; the Giridih field occurring as a small isolated patch to the north of the Damuda Valley; the Daltonganj field, further west, in the Palamau district; the Singareni, Ballarpur, and Warora fields in the Godavari Valley; the Mohpani and Pench Valley fields lying respectively at the northern and southern fringes of the Satpura Range. Before the great depressions now occupied by the Indus, Ganges and Brahmaputra were formed, the Gondwanas probably stretched in great sheets of sandstones, shales and coals as far north as the area now occupied by the Outer Himalaya, and fragments of the strata caught up in the Himalayan folds are now preserved near Darjeeling, in Bhutan, and in North Assam. The coal in these extra-Peninsula patches of Gondwana rocks has been damaged by crushing, but prospecting operations in the Darjeeling district have shown that there is much valuable fuel obtainable in this area.[1]

The north-west ends of the Godavari and Mahanadi belts of coalfields have been overwhelmed by the great sheets of Deccan trap, and no one knows, consequently, how much coal lies hidden under this mantle in the Central Provinces and Berar.

Raniganj field.

The Raniganj field covers an area of about 500 square miles, most of it within the civil district of Burdwan, but stretching also across the boundaries into Bankura, Manbhum, and the Santhal Parganas. The field was surveyed in 1858-60 by W. T. Blanford, and his map, published on a scale of one inch to a mile,[2] has been the recognised guide to the colliery managers. Additional details regarding seams discovered during subsequent mining operations have been added by Dr. W. Saise and Mr. G. A. Stonier to a map published by the *Colliery Guardian*,[3] and a map was prepared, but not published, by Babu Baidyanath Saha showing the distribution of the dykes of basalt and mica-peridotite which traverse the field in great numbers. A few years ago a Committee of the Mining and Geological Institute of India was formed to undertake the revision of the geological map on a scale of four inches to a mile, and Mr. H. Walker

[1] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXIV, p. 212, (1891).
[2] With *Mem. Geol. Surv. Ind.*, Vol. III, Part I.
[3] Supplement: Feb. 10th, 1905, p. 21.

of the Geological Survey was placed on special duty in order to compile the results obtainable from the mine-plans. Thanks to the strenuous assistance given by Mr. R. R. Simpson, Inspector of Mines, and to the willing co-operation of managing agents and colliery managers, the work has been completed and the map published by the Mining and Geological Institute, which body is now undertaking a similar task in connection with the Jherria field.

The subdivisions of the Gondwanas represented on the field are :—

3. *Panchets.*
2. *Damudas :—*
    c. Raniganj stage.
    b. Ironstone shales.
    a. Barakar stage.
1. *Talchirs.*

There is a general dip to the south and south-east throughout the field, and consequently the Talchirs are exposed as a band along the northern margin, succeeded by the younger formations towards the south. As the beds dipping to the south-east are overlapped by the alluvium of the Damuda Valley, the distance to which the coal-bearing rocks extend in this direction towards Burdwan and Calcutta is unknown. In order to test the field in this direction a boring was put down by the East Indian Railway Company in the years 1903 to 1906 at Durgapur, 16 miles south-east of Raniganj, but to the depth of just 3,000 feet the only rocks penetrated were those of the Panchet series and perhaps upper part of the Raniganj stage. At this point, therefore, the coal-seams are buried to a greater depth than 3,000 feet. As the Damuda river stretches away to the south-east in an almost straight line for a distance of about 45 miles beyond the Raniganj field, and thus runs approximately parallel to some great faults within the field, it is possible that its alignment is determined by a great dip-fault, and the Gondwana strata possibly continue along the left bank of the river far beyond the visible limits of the field. Although the Durgapur boring shows that the coal-seams are at that point more than 3,000 feet below the surface, it is quite possible that the depressing effects of the general south-easterly dip may be neutralised by strike faults. Whether the coal measures are brought up in this way to within workable distance of the surface

in the south-east direction, or whether they are now hopelessly beyond reach (if they ever were developed in this area), can only be determined by trial borings to the south-east of Durgapur. So long as there are abundant supplies nearer the surface in the Raniganj and Jherria fields, it will be to no one's financial advantage to risk the money required to test this interesting question.

The information at present available for publication regarding the quality of the coal being worked in the Raniganj field is comparatively limited, for the correlation of the various seams being worked in the different collieries is still doubtful. We are indebted to Dr. W. Saise for a series of assays published in 1904.[1] These show the following extremes and averages:—

TABLE 21.—*Assays of Coal from the Raniganj Field* (*W. Saise*).

—		Moisture.	Ash.	Volatile Matter.	Fixed Carbon.
RANIGANJ (Upper Seams).	Highest . . .	9·05	22·67	38·53	60·50
	Lowest . . .	4·60	8·00	26·40	32·40
	Average of 11 assays .	*6·86*	*14·93*	*32·22*	*45·99*
RANIGANJ (Lower Seams).	Highest . . .	6·20	22·50	38·25	61·00
	Lowest . . .	1·50	8·84	27·00	46·00
	Average of 28 assays .	*3·81*	*13·54*	*31·40*	*51·25*
BARAKAR SEAMS.	Highest . . .	1·50	25·00	29·25	61·00
	Lowest . . .	0·50	11·00	23·75	49·00
	Average of 8 assays .	*1·00*	*17·00*	*26·75*	*55·25*

[1] *Rec. Geol. Surv. Ind.*, XXXI, p. 104.

With variations so wide among the samples these assays are too few to give reliable averages; but they show that the older Barakar seams differ consistently from those of the Raniganj stage in containing less moisture and generally differ by having a smaller percentage of volatile hydrocarbons. This tendency was confirmed by the work of Lieutenant-Colonel F. C. Cunninghame Hughes who investigated the composition and calorific value of a number of samples from various Bengal and Bihar coalfields.[1] His results for the Raniganj field are summarised below:[2]—

—	Moisture per cent.	Volatile matter per cent.	Fixed carbon per cent.	Ash per cent.	Calorific value (in calories).
Raniganj or Upper Measures (average of 22 samples).	4·76	32·16	53·42	9·66	6,767
Barakar or Lower Measures (average of 8 samples).	1·65	24·76	64·05	9·54	7,348

Similar differences have been observed in the coal-seams of the Jherria field. The higher seams of the Raniganj stage also differ from those below by containing generally more moisture and volatile matter with less fixed carbon.

Jherria field.

In the Jherria field the only Gondwana formations preserved are the Talchirs and the three divisions of the Damuda series—the Barakar, Ironstone shales, and Raniganj. The Barakars are by far the most important to the coal-miner, and no attempts were made to work the thinner and poorer seams of the Raniganj series until the 'boom' of 1906-08 led to the opening up of every tolerable seam of coal within range of the two railway systems that serve the field.

[1] *Trans. Min. Geol. Inst. of India*, V, p. 114, (1910).
[2] R. R. Simpson, *Mem. Geol. Surv. India*, XLI p. 49, (1913).

During 1903 a number of coal samples from the Barakar seams was taken by Messrs. E. P. Martin and H. Louis at the working faces in some leading mines in this field. The average of fifteen assays made on these samples was as follows :—

Fixed carbon	63·50
Volatile matter	21·31
Ash	14·29
Moisture	0·90

Ten of these were tested for sulphur and were found to contain on an average 0·57 per cent., while the same ten samples showed an average evaporative power of 12·82 lbs. of water per lb. of coal.

Subsequently in 1909 assays made by Lieutenant-Colonel F. Cunninghame Hughes [1] gave similar results; these are summarised below :[2]—

—	Moisture per cent.	Volatile matter per cent.	Fixed carbon per cent.	Ash per cent.	Calorific value (in calories).
Raniganj or Upper Measures (2 samples).	1·68	30·61	57·26	10·45	7,195
Barakar or Lower Measures (22 samples).	1·25	23·21	63·77	11·78	7,197

The Jherria field, like those of Raniganj and Giridih, is traversed by trap-dykes, the most destructive being a peculiar form of mica-peridotite [3] which spreads out as sheets in the coal-seams destroying large quantities of valuable coal. The seams known as Nos. 14 and 15, which otherwise include a high quality of coal, are especially damaged by trap intrusions in the centre and east of the field.

The Barakars form a crescent-shaped outcrop along the north and east boundaries of the field, the seams of coal being numbered from the margin inwards from 1 to 18. Small faults occur in most parts of the field, but generally in the north and east there is little disturbance and the seams, which dip inwards at gentle angles to the south and west, can be followed with fair confidence; but the

[1] *Trans. Min. Geol. Inst. India*, V, p. 114, (1910).
[2] R. R. Simpson, *Mem. Geol. Surv. India*, XLI, p. 54, (1913).
[3] T. H. Holland, *Rec. Geol. Surv. India*, XXVII, p. 129, (1894).

south-east corner is considerably faulted, the seams generally dip at greater angles, and the correlation of the seams worked in this area with those numbered in the rest of the field is often a matter of conjecture.

The field was first mapped and described by the late T. W. H. Hughes [*Mem. Geol. Surv. Ind.*, Vol. V, part 3, (1866)]. Certain additions and corrections were made after further examination by T. H. Ward in 1890 (*Rec. Geol. Surv. Ind.*, XXV, page 110), and Mr. Ward's map, with further additions by G. A. Stonier, was republished by the *Colliery Guardian* in 1904 (Supplement, September 16th, page 5).

Bokaro and Ramgarh fields.

Immediately west of Jherria on the other side of the Jamunea river lies the western termination of the Jherria field, now sometimes known as the Bokaro-Jherria field. This is being developed by a few Companies and will be served by a short branch line taking off from the Bokaro extension of the Bengal-Nagpur Railway. West of this again lies the Bokaro field, to develop which the Bokaro-Ramgarh Colliery Company was formed a few years ago after obtaining mineral concessions from the Rajah of Padma. A portion of this field is already being developed as a joint colliery between the East Indian and the Bengal-Nagpur Railways, and the joint railway line owned by these two Companies has recently been opened for traffic up to it. The lay-out of the colliery is in progress and the machinery is now being delivered from England. The coal is of good quality, equal to first-class Jherria coal. The small field known as the Ramgarh field lies from 15 to 20 miles south-west of the Bokaro field. It is traversed by the Damuda river, in the bed of which the coal crops out in numerous places. But the coal is not considered, at present, sufficiently attractive for development.[1]

Bye-products recovery.

In the last Review (page 30) reference was made to the erection of bye-product recovery ovens on the Giridih field. Two batteries, one of eighteen, the other of twelve, ovens of the Simon-Carvès type are now installed. The products recovered are tar and ammonia, the latter being converted into ammonium sulphate. The two ovens are said to be capable of producing 40,000 tons of coke annually.[2] The production of sulphate is about 360 to 400 tons per annum. This

[1] This paragraph is based on information kindly supplied by Messrs. G. C. Godfrey and G. C. Lathbury.

[2] T. H. Ward, *Trans. Min. Geol. Inst. India*, IV, p. 351, (1910).

is readily saleable for export to Java and the Straits Settlements, but there is also at last a tendency in India to use artificial fertilizers, and it is hoped that before long the output of ammonium sulphate will be absorbed in this country. The tar is of excellent quality and finds a ready market in Calcutta.

The sulphuric acid used is manufactured at Konnagar near Calcutta from imported sulphur, by Messrs. D. Waldie & Co., who are also recovering in the same way the ammonia in the waste liquors from the Calcutta Gas Works.

Other fields.

The other principal coalfields being worked in the Peninsula are Mohpani, the Pench Valley, and Ballarpur in the Central Provinces, Umaria in the Rewah State, and Singareni in the Nizam's Dominions. Of these Ballarpur has been opened up during the period of the present Review, to take the place of the Warora colliery, which was closed down in 1906.

Ballarpur.

In anticipation of the failure of Warora prospecting operations were undertaken by Government at Ballarpur, 38 miles to the south-south-east in the Chanda district, on the left bank of the Wardha river. Coal was proved by borings over an area of 1½ square miles and a shaft was commenced. The large quantities of water met with in sinking proved to be a formidable obstacle, as all fuel used for the pumping engines had to be carried by road from Warora. Ballarpur was joined to the Great Indian Peninsula system by an extension of the Wardha-Warora branch, which was opened for traffic on the 1st February 1908. Meanwhile two 14-foot circular shafts had been sunk to the coal at depths of 257 feet (No. 1) and 236 feet (No. 2), and in 1906 a small quantity of coal was raised for use on the railway construction works. One of the shafts is lined with brick and ferro-concrete, and the other with fire-bricks moulded to the circle of the shaft.

The seam is 50 feet thick, including thin partings of shale; but the only part at present being worked is an 8-foot layer in the middle of the seam. The workings are on the bord-and-pillar system, the pillars left being 60 feet square. The output between 1909 and 1912 was between 200 and 300 tons a day.

The prospecting operations and development were conducted by Mr. R. Wordsworth while still Manager of Warora, but his head-quarters were subsequently transferred to Ballarpur.

During the year 1912 the coal raised at Ballarpur amounted to 86,417 tons. The expenditure incurred amounted to Rs. 2,35,193, and gross earnings to Rs. 3,51,480, the net profit amounting to 15·56 per cent. on the capital expenditure of Rs. 6,29,941 incurred since the commencement of operations.

Subsequently the colliery was sold to a private firm to whom it was handed over on April 1st, 1913.

The coal at Ballarpur, like most of that obtained from the Gondwanas of the Central Provinces, contains a large proportion of moisture, and also shows inclusions of pyrites. The following two assays were made in the Geological Survey Laboratory on samples obtained when the seam was being first opened up :—

Moisture	11·10	13·51
Volatile matter	31·56	30·61
Fixed carbon	45·47	45·21
Ash	11·87	10·67
	100·00	100·00

The average number of persons employed daily at Ballarpur during the period 1909-13 was 696; there having been only one death during the period, the death-rate stands at the extraordinarily low figure of 0·28 per 1,000.

The annual figures of persons employed are :—

1909	750 persons.
1910	688 ,,
1911	735 ,,
1912	633 ,,
1913	674 ,,

Pench Valley.[1]

In the year 1913 the output of the Pench Valley coalfield was 89,905 tons. The output of coal from this field, however, has, hitherto, been limited by (1) the trade obtaining in the districts served by the Bengal-Nagpur Railway, (2) the carrying capacity of the same railway or rather of that branch of it serving the coalfield.

Three collieries have been opened by the Pench Valley Coal Company, Ltd. :—(1) Chandametta, (2) Barkui, (3) Buteria.

At Chandametta one incline fitted with direct haulage was opened and has been worked out as far as was deemed advisable;

[1] Kindly communicated by Messrs. Shaw, Wallace & Co.

the pillars have been worked back and are now exhausted, with the exception of about 3,000 tons still to get. It is estimated that 93 per cent. of the coal of this area has been won. A barrier has been left between the above workings and a shaft 15 feet in diameter sunk well to the dip, forming a new colliery, which is named Wallace Pit Colliery. It is to be served by the Great Indian Peninsula Railway, which is now laid through the coalfields, and is expected to carry coal about October 1915.

At Barkui one incline was opened and worked up to a certain point. It was then considered that, by reason of danger from flooding from the river which ran past the mouth of the incline and for other reasons, the pillars should be worked out, and a strong barrier left, and a new colliery opened out to the dip. Two inclines have been opened out therefore to the dip of the barrier, which is 300 feet wide.

Collieries are being opened out at Parasia for the Central Pench Coal Company, Ltd., at Jatachapar for the Upper Pench Coal Company, Ltd., at Bhajipani and Eklahra for the Pench River Coal Company, Ltd. All the above collieries are served by the Great Indian Peninsula Railway and are expected to be loading coal for that railway to carry by October 1915.

The Siskol coal-cutters formerly used in this field have been abandoned as the coal eventually proved too hard, and shot holes are now drilled by means of ratchet drills of the Conqueror type.

The average number of persons employed daily during the years 1909 to 1913 was 761 ; this, with 12 deaths, gives a death-rate of 3·15 per 1,000. The annual labour figures are :—

1909	937 persons.
1910	765 ,,
1911	470 ,,
1912	802 ,,
1913	832 ,,

The diamond boring operations at Nimji and Bazargaon, 16 miles to the west of Nagpur, were carried to a depth of 900 feet and abandoned, as no coal was found.

The oldest colliery in the Central Provinces is Mohpani. The

Mohpani.

Mohpani coalfield is situated in the Narsinghpur district on the south side of the Nerbudda alluvial valley, and at the foot of the northern spurs of the Satpuras. The divisions of the Gondwana system

exposed in this field are the Mahadevas, the Barakars, and the Talchirs, the known coal-seams lying, as usual, in the Barakars. About forty years ago, the Sitariva Coal Company carried out a certain amount of work on the field, but the actual development of the Mohpani coalfield is due to the efforts of the Nerbudda Coal and Iron Company, Ltd., which commenced operations in 1862, and, from then until 1904, spent more than £150,000 on the undertaking. The mines are divided into the old field and the new field. The *old field* was abandoned in 1902 after practically the whole of the coal workable to the existing shafts had been won, the total amount so extracted being 450,845 tons, the deepest shaft being the Helen pit, 405 feet deep, and the number of coal-seams four.

The *new field*, forming part of a second concession adjoining the old field, was first opened up in 1892, and up to the end of 1903 the Company had raised 181,080 tons of coal and splint from the two upper coal-seams. As in the old workings on the Sitariva river, faulting and heavy water discharge were, in 1903, giving considerable trouble; so that, in order satisfactorily to work out the already proved coal, additional capital was necessary for hauling and pumping plant. This capital the shareholders of the Nerbudda Coal and Iron Company were unwilling to supply. On the other hand, the Great Indian Peninsula Railway Company, to whose system the mines are connected by a ten-mile branch line to Gadarwada, and who had been taking the output of the Mohpani Collieries at a uniform rate of Rs. 6 a ton, was dissatisfied with the small output; consequently, after a report by Mr. R. R. Simpson of the Geological Survey of India,[1] the properties were sold to the Great Indian Peninsula Railway Company for £40,000 with effect from the 1st July 1904. The results of the change are seen in the rapidly increasing output of this colliery, which sunk as low as 26,618 tons in 1904 and 22,998 in 1905, but has been, on the average, over 50,000 tons in recent years (see table 20).

In the course of his examination of the field, Mr. Simpson made estimates as to the quantity of coal still left to be extracted, and he came to the conclusion that the amount of coal and splint proved by the workings was 1,610,379 tons of coal in Nos. 1 and 2 seams and 411,076 tons of splint in No. 1 seam. In addition to these, he estimated that 725,081 tons could safely be assumed as obtainable

[1] Now Inspector of Mines.

from Nos. 3 and 4 seams, and that an additional quantity of 4,833,902 tons of coal could reasonably be assumed to be obtainable from seams Nos. 1 to 4 and the upper and lower seams of the 1895 area, together with 426,018 tons of splint from No. 1 seam. The grand total thus estimated to be available is 7,169,362 tons of coal and 837,094 tons of splint. In making these estimates, Mr. Simpson has assumed an extraction of two-thirds of the coal worked. The thicknesses of the four seams are:—

No. 1 seam	11 feet of coal with an intermediate band of 6 feet of splint, the specific gravities of coal and splint averaging 1·48 and 1·70 respectively.
,, 2 ,,	25 feet.
,, 3 ,,	5 feet.
,, 4 ,,	6½ feet.

In the 1895 area, the thicknesses are taken as—

Upper seam	18 feet,
Lower seams	9 feet,

the extraction assumed for this area being 50 per cent. In addition, it is considered possible that a considerable quantity of coal may eventually be found in the old field to the dip of the Helen pit at a considerable, but by no means unworkable, depth; but, to prove this, boring will be necessary.

While examining the field Mr. Simpson took ten average samples of coal from seams Nos. 1 and 2 and one sample of the splint in seam No. 1. In 1908, Mr. F. L. G. Simpson, who has been Manager of the Mohpani Collieries since 1882, took a series of twelve samples of coal representing all the four seams (one of them being of the splint) for the purposes of the Nagpur Exhibition. These samples were subjected to approximate analyses in the Geological Survey Laboratory. In table 22 below are given the extremes and means of these twenty-one analyses of coal and of two analyses[1] of splint; and also an average of thirty-nine assays of Bengal coal, taken from Mr. R. R. Simpson's report. Speaking generally, the coal is somewhat inferior to the average of Bengal coals. Mr. R. R.

[1] Some of these, together with some ultimate analyses and coke assays of Mohpani coal by Mr. C. S. Fawcitt of Bangalore, and a complete analysis of ash from No. 1 bottom seam, also by Mr. Fawcitt, are given in the report (L. L. Fermor and J. Kellerschon) on the Mining Section of the Central Provinces Exhibition in *Trans. Min. Geol. Inst. Ind.*, IV, pp. 134 and 135, (1909).

Simpson quotes figures for trials on the Great Indian Peninsula Railway showing the following values :—

Sanctoria (Bengal)	1·00
Singareni	1·18
Mohpani	1·32
Warora	1·57
Umaria	1·62

Sanctoria coal is distinctly superior to the average Bengal coal, and it can be taken that $1\frac{1}{4}$ tons of Mohpani coal are equal to one ton of average Bengal coal.

TABLE 22.—*Assays of Coal from the Mohpani Field.*

—		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calorific value in heat units (*C*).	Evaporative value in lbs. of water.
MR. R. R. SIMPSON'S SAMPLES (1904).	Highest .	4·60	32·04	57·54	35·98	..	..	..
	Lowest .	1·28	17·86	39·50	15·50	..	..	..
	Average of 10 assays.	*2·52*	*24·51*	*48·96*	*24·01*	..	..	..
	Splint .	2·84	21·02	37·90	38·24	..	..	..
MR. F. L. G. SIMPSON'S SAMPLES (1908).	Highest .	5·97	34·20	53·03	22·94	0·79	7,187	13·38
	Lowest .	4·06	25·65	43·96	9·79	0·23	5,573	10·38
	Average of 11 assays.	*5·28*	*29·81*	*48·31*	*16·57*	*0·37*	*6,427*	*11·97*
	Splint .	3·68	23·06	31·94	41·32	0·85	4,400	8·19
BENGAL COAL-FIELDS.	*Average of 39 assays.*	..	31·30	53·70	15·00	..	..	..

The average number of persons employed daily at Mohpani during the period under review was 1,110, the annual figures being as follows :—

1909	1,224
1910	966
1911	1,087
1912	1,095
1913	1,178
Average .	1,110

The number of deaths was two, giving an average annua death-rate for the period of 0·36 per 1,000, a very low figure.

Singareni.

The great belt of Gondwana rocks, near the north-west end of which Warora is situated, stretches down the Godavari valley as far as Rajamundry, and at one or two places the equivalents of the coal-bearing Damuda series in Bengal are found cropping up from below the Upper Gondwana rocks. One of these occurrences near Yellandu in the Nizam's Dominions forms the coalfield well known by the name of Singareni. The principal seam of coal, some 5 to 6 feet thick, being worked at the Singareni colliery, was discovered by the late Dr. W. King of the Geological Survey in 1872, but mining operations were not commenced until 1886, since when the output has rapidly risen to over 500,000 tons a year.

Coal-mining at Singareni has, as in previous periods, been accompanied by a heavier loss of life by accidents than in most Gondwana fields. Table 23 shows the death-rate on this field compared with the rate in Bengal. The average figure for the five years 1909 to 1913 (2·05 per 1,000) is higher than that for the period of the previous review (1·55 per 1,000).

TABLE 23.—*Death-rate from Accidents at Singareni compared with Bengal.*

	—	1909.	1910.	1911.	1912.	1913.	*Average.*
SINGARENI.	Numbers of persons employed.	8,517	9,031	7,860	8,315	10,028	*8,750*
	Deaths from accidents .	8	16	23	15	28	*18*
	Death-rate per 1,000 employed.	0·94	1·77	2·92	1·80	2·79	*2·05*
Death-rate in Bengal coalfields		*0·97*	*1·26*	*1·18*	*1·19*	*1·28*	*1·18*

Umaria.

The Bilaspur-Katni branch of the Bengal-Nagpur Railway passes through the small coalfield of Umaria in the Rewah State, Central India. The quantity of workable coal in this field is estimated at about 24,000,000 tons. During the periods of the two previous reviews the average annual output has been about 170,000 tons. During the

period under review the output has fallen considerably, the annual average being less than 139,000 tons (see table 20). This is due to the fact that the Great Indian Peninsula Railway, which takes a large proportion of the output, is now able to obtain an increasing supply from Mohpani, and also to draw on the Pench Valley mines. The three coal-seams being worked vary from about 3 to 12 feet in thickness and dip at about 4° to the north-east. The mines were opened in 1882 under the direction of Mr. T. W. H. Hughes of the Geological Survey and were controlled by Government until the 1st January 1900, when they were handed over to the Rewah State, to which they are a source of considerable profit, the annual net earnings during the period under review amounting to about Rs. 2,50,000, except in the year 1908-09, when the earnings fell to about Rs. 1,50,000.

The average number of persons employed daily at Umaria during the period under review was 1,687, the figures for each year being as follows:—

1909	1,505
1910	1,398
1911	1,430
1912	2,511
1913	1,593
Average	*1,687*

The number of deaths was six, giving an average death-rate for the period of 0·71 per 1,000 employed.

Korea.

In 1913 a geological examination of the coalfields of Korea State, Central Provinces,[1] was carried out. The northern or Sanhat field contains two principal seams, the lower of which is valueless in the western half of its course, but shows thicknesses of 4 to 9 feet over a length of 16 miles in the eastern part of the field. The upper seam is valueless in the east, but ranges from 3½ feet to nearly 10 feet in the west. The result of a considerable number of assays shows that neither seam is of good quality, the ash content ranging from 15·38 per cent. to 32·24 per cent. in the case of the lower seam and from 22·98 to 36·68 per cent. in the case of the upper. In the Kurasia section of the Kurasia field 6 coal horizons were found,

[1] L. L. Fermor, *Mem. G. S. I.*, XLI, pt. 2.

in one of which (horizon 4) there are from 2 to 5 seams, ranging in thickness from 1 foot to 8 feet 6 inches. This horizon is supposed to cover about 4 square miles, in which case an average thickness of the coal of, say, 5 feet would correspond to 5½ million tons per square mile. This, however, must still be proved by boring. Numerous samples taken show that the coal of this area is better than that of the Sanhat field, the ash content ranging from 9·32 per cent. to 13·82 per cent.; the average composition of all the samples taken is shown below.

Still better coal is found in the Chirmiri section of the Kurasia field, where the finest seam of coal in the State is exposed in the Kauria stream at and below a waterfall known as the Karar Khoh. Seven seams, aggregating 38 feet in thickness, were observed, the average assay value being shown in the following table:—

TABLE 24.—*Assays of Coal from Korea State.*

—	SANHAT FIELD.		KURASIA FIELD (HORIZON 4).	
	Seam No. 1 (Lower).	Seam No. 2 (Upper).	Kurasia area.	Chirmiri area (Kauria Nala).
Number of analyses	3	5	6	10
Moisture	5·79	4·19	8·66	7·94
Volatile matter	28·22	24·00	30·92	29·68
Fixed carbon	44·80	44·00	48·86	51·20
Ash	21·19	27·81	11·56	11·18
	100·00	100·00	100·00	100·00

This series of seams appears to thin out gradually in all directions; but it is considered that there is from 1 to 1½, possibly even 2, square miles, over which the coal is at least 10 feet thick. It is estimated, therefore, that at least 7 million tons of good coal are available, possibly a considerably larger quantity. The dip of the seams is always very low, usually almost horizontal.

In the foot-hills of Bhutan[1] coal has been found near the Kala Pani as highly-inclined crushed lenticular seams near the junction of the enclosing Gondwana rocks with the Siwaliks, which is marked by a reversed fault. The coal is of poor quality, friable, and does not seem to occur in any large quantity, the total length of outcrop at the principal locality being 900 feet, and the average total thickness not more than 12 feet.

Bhutan.

Tertiary Coalfields.

As has already been noted (see page 44), all the coal being worked outside the Gondwana coalfields is of Tertiary age. Coal of this age is found in Baluchistan, Sind, Rajputana, the Punjab, along the foot-hills of the Himalaya, further east in Assam, in Burma, and in the Andaman and Nicobar Islands. The most frequent occurrence is in association with nummulitic limestones (Eocene), although the richest deposits, *viz.*, those in North-East Assam, are younger, probably Miocene, in age. The output from each of these Tertiary fields for the years 1909 to 1913 is shown in table 25. From this table it will be seen that the output of Tertiary coal during the period under review averages over 400,000 tons a year.

On the whole, the younger coals, which are being worked in extra-Peninsular areas, differ from the Gondwana coals in containing a larger portion of moisture and volatile hydrocarbons, and though as variable in composition as they are in thickness of seam, coals are obtained, as for instance in Assam, with a remarkably low percentage of ash and having a high calorific value. The high proportion of moisture in some of these younger coals is, however, often a serious cause of deficiency in calorific value. The difference between the Tertiary coals and Gondwana coal from Bengal is well seen in the following table, which gives the extremes and averages of analyses of five samples of coal from Assam, two from Baluchistan, one from Burma, and five from the Punjab, given in a paper on the "Composition and Quality of Indian Coals" by Professor W. R. Dunstan;[2] and also the average of thirty-nine samples of Bengal coal by Mr. R. R. Simpson, given on page 59.

[1] G. E. Pilgrim, *Rec. Geol. Surv. Ind.*, XXXIV, pp. 31—36, (1906).

[2] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 241-253, (1906). The results tabulated in this paper are supplementary to those given in the *Indian Agricultural Ledger*, (No 14, 1898), and *Journ. Soc. Arts*, L., pp. 371—407, (1902).

TABLE 24.—*Production of Tertiary Coal during the years 1909 to 1913.*

COALFIELD.	1909. Tons.	1909. Per cent. of Indian Total.	1910. Tons.	1910. Per cent. of Indian Total.	1911. Tons.	1911. Per cent. of Indian Total.	1912. Tons.	1912. Per cent. of Indian Total.	1913. Tons.	1913. Per cent. of Indian Total.
Assam—										
Makum	305,563	*2·57*	297,236	*2·47*	294,893	*2·32*	296,615	*2·02*	270,364	*1·67*
Khasi and Jaintia Hills	..		..		..		545		498	
Baluchistan—										
Khost	40,237	*·34*	43,428	*·36*	42,410	*·33*	45,477	*0·31*	45,585	*·28*
Ser Range, Mach, etc.	12,212	*·10*	9,186	*·08*	3,297	*·03*	8,909	*0·06*	7,347	*·05*
North-West Frontier Province—										
Hazara	96		90		140		50		90	
Punjab (Salt Range)—										
Jhelum District	34,135	*·32*	46,655	*·41*	26,982	*·24*	33,192	*0·26*	46,155	*·31*
Mianwali	45		1,884		2,522		1,600		..	
Shahpur	3,028		650		1,071		3,617		4,885	
Rajputana—										
Bikaner	11,449	*·10*	12,744	*·10*	14,761	*·12*	18,251	*0·12*	18,781	*·12*
Total Tertiary Beds	**406,765**	*3·43*	**411,873**	*3·42*	**386,076**	*3·04*	**408,256**	*2·77*	**393,705**	*2·43*

TABLE 26.—*Average Assays of Tertiary and Gondwana (Bengal) Coals.*

		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calorific value in heat units (C).	Evaporative value in lbs. of water
Tertiary: higher grade: Assam and Baluchistan—	Highest .	5·83	46·48	53·28	9·56	4·87	7,702	14·34
	Lowest .	1·45	40·42	41·50	1·27	0·74	6,028	11·22
	Average of 7 assays.	*3·19*	*43·58*	*48·99*	*4·24*	*3·14*	*6,926*	*12·90*
Tertiary: lower grade: Burma and Punjab—	Highest .	10·85	47·08	39·44	39·91	4·41	6,730	12·53
	Lowest .	3·47	26·85	27·79	8·50	0·33	4,270	7·95
	Average of 6 assays.	*6·56*	*38·89*	*34·57*	*19·98*	*1·91*	*5,610*	*10·45*
Bengal coalfields .	*Average of 39 assays.*	..	*31·30*	*53·70*	*15·00*	..	..	..

North-East Assam.

The most promising amongst these young coals is the group of occurrences in North-East Assam, one of which is now being worked by the Assam Railways and Trading Company, which commenced operations at Makum (27° 15′; 95° 45′) in 1881. The collieries are connected by a metre-gauge railway with Dibrugarh on the Brahmaputra river, which being navigable forms both a market and a means of transport for the coal. The coal-bearing rocks to which the Makum field belongs stretch for 40 miles to the north-east, and can be traced for 100 miles to the south-west, along the northern front of the Patkai range. The most valuable seams occur between the Tirap and Namdang streams, where for a distance of about 5 miles, the seams vary from 15 to 75 feet in thickness. Near Margherita, where the collieries are situated, the average thickness of the thickest seam now being worked is about 50 feet of coal, with intercalations of fire-clay amounting to 10 feet;

in the Namdang section it increases to as much as 80 feet, and is persistent, with little variation, for a distance of 6 miles. The average dip is 40°; but as the outcrops in many places are several hundred feet above the plains, facilities exist for working the coal by adit levels. The average coal production of the Makum mines during the last five years has been 292,934 tons a year, as compared with 279,833 tons during the previous period. The coal has the reputation of being a good fuel, and forms an excellent coke. Mr. R. R. Simpson has sampled the coal-seams being worked in the Upper Ledo and Tikak mines in this field.[1]

The average compositions given by three samples from the Upper Ledo Colliery and representing an aggregate thickness of 49 feet, and five samples from the Tikak Colliery representing an aggregate thickness of 47 feet, are shown below:—

	Upper Ledo.	Tikak.
Moisture	1·80	2·09
Volatile hydrocarbons	40·15	37·25
Fixed carbon	55·59	58·99
Ash	2·46	1·67
TOTAL	100·00	100·00

Mr. Simpson[2] has also examined the Jaipur and Nazira coal-fields lying to the south-west of the Makum field. Of these the latter is now being opened up.

He confirms the estimate previously made by Mr. Mallett with regard to the large quantity of good fuel in these two fields; in addition to the estimates of coal that can be proved, there is the probability of larger quantities hidden by the alluvial deposits; but in many places the seams are highly inclined, and, being below the level of permanent saturation, will be difficult to work except with special precautions to deal with the water. The most promising mining proposition is in the neighbourhood of the Dikhu river, where $2\frac{1}{4}$ million tons of coal would be certainly obtainable, the chief difficulty to be overcome in this case being transport. The quality of the coals from these two fields is shown by a series of analyses (*l.c.*, pages 227—230), which are summarised below. The sulphur in five of the Jaipur coals averaged 1·87 per cent., and in five of the Nazira coals 3·35 per cent.

[1] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 239-241, (1906).
[2] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 199-238, (1906).

Coal of excellent quality also occurs in the Namchik valley, a tributary on the left bank of the Dihing R., three days' journey above Margherita. The locality, which, although only 18 miles is a straight line from Ledo, is difficult of access, was examined by Mr. E. H. Pascoe in 1911. Five groups of seams were noticed, with a total thickness of about 60 feet of coal.[1]

TABLE 27.—*Assays of Coal from the Jaipur and Nazira Coalfields.*

—		Moisture.	Volatile matter.	Fixed carbon.	Ash.
JAIPUR FIELD	Highest . .	10·31	45·10	53·71	18·18
	Lowest . . .	3·95	35·49	41·38	1·10
	Average of 25 assays	*6·42*	*39·80*	*48·78*	*4·82*
NAZIRA FIELD	Highest . .	7·23	42·90	54·64	14·45
	Lowest . . .	3·89	34·36	45·49	2·22
	Average of 12 assays	*5·49*	*38·11*	*50·04*	*6·36*

Burma.

Coal occurs in various parts of Burma, but the only district from which there has been any regular output is Shwebo from which there were returns varying between 6,975 and 13,302 tons during the period 1898-1903. In February 1904, with the closing of the Letkopin mines, however, this district ceased to be a producer, and since that year the only output from Burma has consisted of small quantities extracted during prospecting operations.

Accounts have been published of the previously known fields near Lashio[2] and Namma and of two fields near Mansang and Man-se-le.[3]

[1] *Rec. Geol. Surv. Ind.*, XLI, p. 214, (1912).
[2] T. D. LaTouche and R. R. Simpson, *Rec. Geol. Surv. Ind.*, XXXIII, pp. 117—124, (1903).
[3] R. R. Simpson, *Rec. Geol. Surv. Ind.*, XXXIII, pp. 125—156 ; see also pp. 86—88.

All the four fields are situated in the Northern Shan States; they form an isolated basin lying on the prevalent Plateau limestones, and consist of sand, shale, and lignitic coal, probably of Pliocene age. In all these fields the coal is lignitic, containing large quantities of moisture (10 to 23 per cent.), very low percentages of fixed carbon (9 to 40 per cent.), with very variable, often very high, quantities of ash. The best lignite seems to be that of the Namma field, but the cost of mining, briquetting, and transport of this fuel is more than its present value; it might be possible economically to briquette Lashio fuel, when it would be of service on the railway as far west as Maymyo.

Coal has long been known to occur also in the Henzada district, but the prospects of successful exploitation are doubtful. The chief outcrops are at Posugyi, Kywezin, Hlemauk and Kyibin. Of these Kywezin seems to be the only area worth further attention; the coal there is very friable and greatly crushed, whilst the seam, which is about 10 feet thick, is much contorted; otherwise, its quality is good.

Baluchistan : Khost.[1]

Possibly the most important of the coal deposits in the west occur in Baluchistan, where, however, the disturbed state of the rocks renders mining operations difficult, expensive, and often dangerous. Besides the small mines in the Sor range, south-east of Quetta, and in the Bolan pass at Mach, collieries have been worked since 1877 at Khost (30° 12′; 67° 40′) on the Sind-Pishin Railway. The two seams being worked have an average thickness respectively of 26 and 27 inches. During the period of the previous review, the output averaged 33,228 tons per annum. During the quinquennial period 1909-13, the output increased considerably, the average being 43,448 tons per annum. This consists mainly of steam and dust coal, with a small proportion of nut. Most of the dust coal is converted into pressed fuel, the quantity so manufactured averaging about 20,000 tons a year. This is sold at Rs. 12 to Rs. 17 per ton, the price of the steam coal being Rs. 10-8 to Rs. 18-2.

During the period under review, work was, on the whole, carried on at a profit at these collieries, which are under the control of the North-Western State Railway; during the year 1912 work resulted in a loss (see table 28). This period, however, compares

[1] An account of these mines, written by the manager, Mr. A. Mort, will be found in *Trans. Min. Geol. Inst. India,* VII, p. 295, (1913).

favourably with the previous one, during which there was a considerable loss. The output per person employed at Khost has averaged only 46 tons per annum during the period under review, and although the death-rate (6·4 per thousand) is much less than in the period previously reviewed (10·9 per thousand), yet it is still abnormally high.

Besides the stratigraphical difficulties arising from working Tertiary coal-seams, which are often irregular in thickness and lie in disturbed, uncertain ground, there are additional dangers due to the liability of most of these pyritous coals to spontaneous combustion, and to the danger of explosion by the large quantities of dust generally formed in working such friable coals. To these natural difficulties is added a serious scarcity of trained labour.

TABLE 28.—*Summary of the Financial Results of working the Khost Colliery during the years 1909 to 1913.*

Year.	Gross earnings.	Working expenses.	Financial result.	
			Net earnings.	*Percentage on capital.*
	£	£	£	
1909	26,292	24,644	1,648	*8·33*
1910	28,743	25,659	3,084	*15·61*
1911	23,283	22,785	498	*2·66*
1912	22,515	23,083	—568	..
1913	21,646	21,317	329	*1·99*

Punjab : Dandot.

The coal that has been most worked in the Punjab is that long known to exist in the Jhelum district, on the Dandot plateau of the Salt Range. The only available seam varies in thickness from 18 to 39 inches, forming a basin under the nummulitic limestone. The mines at Dandot and at Pidh, 3 miles to the north-east, were worked for the North-Western Railway from 1884 till 1912, when the railway decided to close work and sell the mines and plant as a going concern. These were purchased by Messrs. Thakur Dass and Ramji Dass, who have worked the mines since June 1912. During the

period under review, the output from these collieries has fluctuated between 26,982 tons in 1911 and 46,655 tons in 1910, the average figure being 37,420 tons a year. This is considerably less than the output during the period previously reviewed, but the sudden fall in 1911 was due to the decision of the railway company to employ Bengal coal in their locomotives and to give up further mining operations at Dandot. In 1912 and 1913, the output rose again, though in no year was it as high as the average annual output of the previous quinquennium. The annual output of coal per miner employed at Dandot during the last five years has averaged only 35·6 tons against about 107 tons turned out per man in Bengal; the loss of life through accidents was considerably higher than in 1904-08, being 2·3 per 1,000 people employed as against 0·71.

Punjab : Shahpur district.

Coal-seams, similar to those of Dandot and Bhaganwala in the Jhelum district, are known to occur further west in the Shahpur district, the principal localities being Tejuwala near the crest of the southern scarp of the Salt Range, 12½ miles slightly west of north from Dhak on the Sind-Sagar branch of the North-Western Railway, and at Jhakarkot, 3½ miles south-west of Tejuwala. A small amount of work was prosecuted in 1890, but abandoned after the extraction of a few hundred tons of coal. Work was commenced on these deposits by Messrs. Bhagwan Das and Ram Das in 1905, and, during the three succeeding years, some 40,000 tons of coal were won. During the period under review, however, the total output of the Shahpur field has been only 13,249 tons, giving an annual average of a little over 2,600 tons.

Punjab : Dilwal borings.

In order to ascertain whether there was any likelihood of a coalfield of any extent being hidden beneath the Salt Range plateau to the north of the Dandot-Nurpur scarp, borings were put down, during the years 1910 and 1911, near Dandot and also on the Dilwal plateau at the villages of Tothral and Arar, which lie some considerable distance back from the scarp. In all cases the results were unpromising; near Dandot the seam was met with at 309 feet below the surface, but was only 1 foot 10 inches thick; at Tothral the seam was thinner still (1 foot 4 inches), while at Arar no coal was met with in the boring. It is not probable therefore that coal of any value lies beneath the limestone cover in that part of the Salt Range.

Rajputana : Palana.

Mining operations on the lignite of Palana in the Bikanir State, Rajputana (see page 64), were commenced in 1898 at a point where the seam was found to be 20 feet thick, and a branch line, 10 miles long, to the Jodhpur-Bikanir Railway, was constructed for the systematic development of the colliery. On account of the uncertainty regarding the horizontal extension of the seam, the output is restricted. Thus, whilst the returns for the previous review show a steady fall in output from 45,078 tons in 1904 to 21,297 tons in 1908, the figures for the period now under review show a small but steady rise from 11,449 tons in 1909 to 18,781 tons in 1913. The physical characters of the natural fuel form a drawback to its use in locomotives; but during December 1908 and January 1909, trials were made with briquettes manufactured in Germany from Palana coal and proved that the coal in briquette form would be a valuable factor for locomotive work.[1] The proportion of moisture is reduced, and the fuel made less susceptible to atmospheric action. Briquetting plant cannot, however, be erected until the coal output at the mines has been increased.

Labour.

Coal-mining, from the point of view of labour, still remains by far the most important of all forms of mining in India. During the period under review the average number of persons employed daily was 125,862, being on the average 21,000 higher than the figure for the previous quinquennium. The rise in the amount of coal produced, however, was more than commensurate with the rise in numbers and gives evidence of increased efficiency in the mining methods employed. The provincial distribution of labour is shown in table 29, from which it will be seen that the share taken by the Bengal and Bihar coalfields has again increased, over 86 per cent. of the Indian colliery workers being employed in those provinces.

Efficiency of the Indian collier.

Attention has been directed in previous reviews to the low efficiency of the Indian coal-miner compared with that of the collier in most other countries. Part of this apparent low efficiency has been due to the simplicity of the shallow mining operations, permitting the use of simple cheap labour with little machinery.

[1] W. H. Phillips, 'The Manufacture of Patent Fuel,' etc., *Trans. Min. Geol. Inst., India*, VI, p. 43, (1911).

TABLE 29.—*Number of persons employed in the Indian Coal-Mining Industry during the years 1909 to 1913.*

PROVINCE.	1909.	1910.	1911.	1912.	1913.	*Average.*	Per cent. of average total.
Assam . . .	1,795	1,925	1,965	2,143	2,478	*2,061*	1·64
Baluchistan . .	1,105	1,073	932	1,161	1,087	*1,072*	·85
Bengal . . .	34,687	34,322	33,931	36,828	38,561	*35,666*	28·34
Bihar and Orissa .	67,566	63,959	66,052	77,924	87,452	*72,590*	57·67
Central India .	1,505	1,398	1,430	2,511	1,593	*1,687*	1·34
Central Provinces .	2,911	2,419	2,292	2,530	2,684	*2,567*	2·04
Hyderabad . .	8,517	9,031	7,860	8,315	10,028	*8,750*	6·95
North-West Frontier Province.	4	5	5	2	6	*4*	..
Punjab . . .	1,223	1,782	1,505	981	892	*1,277*	1·02
Rajputana (Bikanir).	233	167	183	172	185	*188*	·15
Total .	**119,546**	**116,081**	**116,155**	**132,567**	**144,966**	*125,862*	100·00

The strings of coolie women carrying out coal along the inclines formed the most prominent feature of the fields in the old days. These are now naturally giving way to well-equipped installations for haulage, both through inclines and shafts. Table 30 shows that while there has been a greater output per person employed during the past quinquennial period than that shown by the returns of previous periods, there has also been a slight increase in efficiency during the past five years. The apparently slow improvement is partly due to the fact that little change has occurred in the numbers of workers required at the surface. The increased use of machinery with the deepening and extension of the mines shows up more distinctly in table 31, which gives the output of coal per person employed below ground. During the past five years this output has increased from 153·1 to 172·1 tons per person employed below ground.

TABLE 30.—*Output of Coal per Person employed at Indian Mines during the years 1909 to 1913.*

YEAR.	Average daily attendance of workers.	Output.	*Output per person employed.*
		Tons.	*Tons.*
1909	119,546	11,870,064	*99·2*
1910	116,081	12,047,413	*103·7*
1911	116,115	12,715,534	*109·4*
1912	132,567	14,706,339	*110·9*
1913	144,966	16,208,009	*111·8*

TABLE 31.—*Output of Coal per Person employed below ground during the years 1909 to 1913.*

YEAR.	Average number of persons employed daily below ground.	Output.	*Output per person employed below ground.*
		Tons.	*Tons.*
1909	77,532	11,870,064	*153·1*
1910	75,950	12,047,413	*158·6*
1911	76,284	12,715,534	*166·7*
1912	86,316	14,706,339	*170·4*
1913	94,144	16,208,009	*172·1*

Table 32 shows how the efficiency of the Indian worker compares with that of the collier in other parts of the British Empire; but it should be remembered that this is not a true index of personal efficiency; in countries where labour is more expensive, and where mining operations are necessarily conducted at greater depths, the use of machinery becomes imperative.

TABLE 32.—*Amount of Coal raised per Person employed at Coal Mines in the British Empire.*

COUNTRIES.	1910.			1911.		
	Persons employed.	Tons of coal raised.	Tons per person.	Persons employed.	Tons of coal raised.	Tons per person.
United Kingdom	1,032,702	264,433,028	256·0	1,049,897	271,891,899	258·9
Australia (*a*) .	21,494	9,676,549	450·2	21,546	10,493,060	487·0
Canada (*b*) .	24,577	11,327,771	460·9	26,084	10,019,166	384·1
Cape Colony .	1,501	87,551	58·3	1,114	79,485	71·3
Natal . .	10,043	2,294,746	228·4	9,824	2,392,456	243·5
New Zealand .	4,599	2,197,362	477·7	4,290	2,066,073	481·6
Orange River .	1,574	474,742	301·6	1,574	430,973	273·8
Transvaal .	8,795	3,548,550	403·4	8,830	3,878,286	439·2
British Empire, except India.	**1,105,285**	**294,040,299**	**266·0**	**1,123,159**	**301,251,398**	**268·2**
India . .	116,081	12,047,413	103·7	116,155	12,715,534	109·4

(*a*) Excluding Tasmania, which produced 83,768 tons of coal in 1910 and 57,983 tons in 1911.
(*b*) Represents British Columbia, Nova Scotia and Alberta.

We are indebted to the officers of the Department of Mines for the following note on the use of electricity and coal-cutting machinery in the Bengal Coal Mines :—

Use of Electricity.

Electricity has now established itself as a recognised form of power in Indian mines, and the strides it has made in the last few years are an indication of the degree to which it will be applied in future. There is no doubt that the electrification of the majority of our large mines is only a question of time, but it is probable that this end would have been attained much earlier, had it been effected through the agency of central supply companies, instead of being left to individual enterprise, because the initial cost of an isolated electrical plant, sufficient for the maximum requirements of a fully developed mine, is great compared with the sum Colliery Companies are accustomed to provide, from time to time, as the mines develop, and frequently from current revenue account, for mechanical power. The paucity of bye-product coke ovens and of blast furnaces, and the neglect to utilise exhaust

steam from colliery engines, have all contributed to raise the cost of the production of electricity; but in spite of this a very substantial economy has resulted from the installation of existing plants, and more particularly where compressed air has been replaced.

Pumping, hauling and lighting are the principal uses to which electricity is now applied. There are several electric winding engines on order for use in the coal-fields and there is little doubt that this most modern form of machine will find considerable favour in future. The gradual removal of steam pumps and hauling engines from the shaft bottoms and underground workings is compelling the introduction of ventilating machines for maintaining the ventilation of mines, and many of these are already driven electrically. The invention of variable speed motors has made this form of power convenient for this purpose.

Comparative freedom from gas in our mines has permitted the use of high pressure and already pressures of 3,300 volts are carried to the pit bottom where it is stepped down to about 500 volts for use inbye. Pressures of 5,000 and 7,000 volts are contemplated for transmission purposes.

It is a striking testimony to the adaptability of the Indian colliery mechanic that he can be readily trained to manipulate electric machines, to effect petty repairs and even to wind motors under European supervision.

Wherever electricity has been installed the illumination of the pit bank and pit bottom has been one of its first uses and very great convenience has resulted.

Altogether there has been a distinct advance in the use of electricity since the issue of the last review. It is doubtful whether a modern colliery will be able to work successfully in the future unless it is electrically equipped.

Coal-cutting machinery.

On the other hand, there is now little or no coal-cutting by machinery. During the time of high prices which prevailed round and about 1908, owners strove to put out more and more coal, even at an enhanced cost, and outputs increased rapidly. The labour supply was found soon to be inadequate, and a number of owners put down and carried on successfully coal-cutting plants, although at a somewhat high cost. As prices dropped, and labour conditions became easier, the cost of production by the machines became relatively too high, and they were discarded. Occasionally a plant is put down for the purpose of making long connections underground rapidly.

As long as labour conditions remain as they are, there will not be much headway in the introduction of mechanical coal cutters.

The detailed description of the Equitable Coal Company's mines at Dishargarh, given by Mr. W. Miller in the *Transactions of the Mining and Geological Institute of India,* Vol. III, part 3 (1909), and the remarks thereon by Mr. W. C. Mountain in Vol. IV, part 2, will give a good idea of the equipment of one of the advanced types of collieries in Bengal.

Sanitation.

Coal-mining has developed so rapidly during the past few years in the Jherria and Raniganj fields that the mine managers, finding it necessary to spend their main energies in meeting the demand

for coal, have been able to spare little time and thought for the general well-being of the rapidly increasing community of workers. Commendable care has been exercised in individual cases to provide suitable accommodation for the miners, and filter installations have been erected to render the available water as nearly as possible innocuous; but there had until recently been little or no combination of the Companies concerned to arrange for systematic sanitation and a sufficient or trustworthy water-supply for the whole community. The majority of workers are drawn from the aboriginal tribes, whose simple habits in sparsely inhabited jungles and cultivated areas are unsuitable to the more crowded conditions of industrial centres; they have yet to learn the value of sanitation and the advantages of the attempts made by the colliery owners to guard them from their new dangers. The disastrous epidemic of cholera, which resulted in about 5,000 deaths on the Jherria and Raniganj fields during the early months of 1908, impressed upon the owner as well as upon the worker the dangerous state of unstable equilibrium developed in the mining community. The subsequent drop in the demand for coal and consequent reduction in the feverish haste to increase the output gave the owner time to reconsider his methods of economising his mineral possessions and to give more thought to the equally important duty of looking after the health and happiness of his miners. One result of this is to be seen in the scheme evolved for a water-supply for the Jherria field to be brought from near Topchanchi at the southern foot of Parasnath.

Death-rate from accidents.

Attention has been directed in previous reviews to the low average death-rate from accidents in Indian coal-mines. The average annual death-rate per 1,000 persons employed during the years 1898 to 1903 was 0·88, varying between 0·68 (1898) and 1·32 (1899). During the next quinquennial period the rate was slightly higher, working out to 0·98 per 1,000 for all Indian coal mines, and varying between 0·72 in 1904 and 1·37 in 1908. Risks naturally increase with the deepening of the mines and general extension of the workings, while additional dangers may be incurred by the haste to increase the output during periods of urgent demand for coal. The agreement of results with exceptions may, however, be fortuitous, for the totals are so small that an isolated disaster, such as that which occurred at Chowrasi in the Raniganj field on the 22nd October

1913, when twenty-seven workers were killed, would have a disturbing effect on the average. It is true, however, that there has been a distinct rise in the average death-rate during the five years ending with 1913, the figure being 1·38 per 1,000 persons employed; the actual figures varied from 1·07 in 1909 to 1·52 in 1910 (see table 33).

TABLE 33.—*Production of Coal compared with Deaths from Coal-Mining Accidents in India.*

——	1909.	1910.	1911.	1912.	1913.	*Average.*
Deaths from coal-mining accidents.	128	177	175	174	214	*174*
Thousands of tons of coal raised for each life lost.	92	68	72	84	75	*77*
Lives lost per million tons of coal raised.	10·7	14·6	13·7	11·8	13·2	*12·8*
Death-rate per thousand persons employed.	1·07	1·52	1·50	1·31	1·47	*1·38*

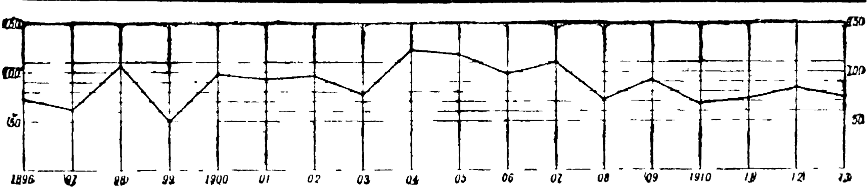


FIG 9.—*Production of coal per life lost by coal-mining accidents.*

The coal mines, like all other mines, in British territory are worked under rules framed in accordance with the provisions of the Indian Mines Act (No. VIII of 1901), and are subject to constant official inspection. The Inspectors are also invited at times to inspect the mines being worked in Native States; and, although the returns from these latter show on an average a higher death-rate from accidents, it cannot be said that the difference is due to any differences in management, for the great number of mines in Bengal and Bihar under the Act (which largely control the averages) are worked under exceptionally favourable conditions, while some of those in Native States, as for instance in Bikanir and

Hyderabad, are exposed to special dangers. During the period under review the average annual number of deaths from accidents at coal mines in Native States was 20 against 154 at mines under the Act, the death-rate being 1·88 per thousand in the former case against 1·33 per thousand at mines under the Act. The details for each year are given in table 34, from which it will be seen that, while there has been very little change in the labour returns at mines in Native States, there has been a great increase of employment at mines worked under the Act from a total of 105,485 in 1910 to 133,160 in 1913.

TABLE 34.—*Comparison of Death-rate from Accidents at Coal Mines worked under the Mines Act with those in Native States during 1909-1913.*

YEAR.	AVERAGE NUMBER OF PERSONS EMPLOYED DAILY.		DEATHS FROM ACCIDENTS.		DEATH-RATE PER 1,000 PERSONS EMPLOYED.	
	Mines under the Act.	*Native States.*	Mines under the Act.	*Native States.*	Mines under the Act.	*Native States.*
1909	109,291	*10,255*	119	*9*	1·08	*0·87*
1910	105,485	*10,596*	160	*17*	1·51	*1·60*
1911	106,682	*9,473*	148	*27*	1·38	*2·85*
1912	121,569	*10,998*	157	*17*	1·29	*1·54*
1913	133,160	*11,806*	185	*29*	1·38	*2·45*
Average	*115,237*	*10,625*	*154*	*20*	*1·33*	*1·88*

The returns for accidents at Indian coal mines are compared with those of other parts of the British Empire in table 35. The comparison is much less favourable to India than was the similar comparison for the years 1905 and 1906, given in the previous Review. But the gradual change in mining conditions in India, from shallow to deep, cannot but affect these statistics, and it is only owing to the vigilance of those employed in mining as well as to those employed in administering the Mines Act, that the death-rate is not higher than it is.

TABLE 35.—*Death-rate from Coal-Mining Accidents in the British Empire.*

COUNTRIES.	1910.				1911.				1912.			
	Number employed.	Deaths.	*Death-rate per 1,000.*	Deaths per 1,000,000 tons coal raised.	Number employed.	Deaths.	*Death-rate per 1,000.*	Deaths per 1,000,000 tons coal raised.	Number employed.	Deaths.	*Death-rate per 1,000.*	Deaths per 1,000,000 tons of coal raised.
United Kingdom.	1,032,702	1,754	*1·70*	6·63	1,049.897	1,232	*1·17*	4·53	1,072,393	1,258	*1·17*	4·77
Australia (*a*) .	21,494	29	*1·34*	2·99	21.546	19	*·88*	1·81	21,842	32	*1·46*	2·74
Canada (*b*) .	24,577	119	*4·84*	10·50	26.084	59	*2·26*	5·88	27,088	79	*2·91*	6·12
Cape Colony .	1,501	2	*1·33*	22·84	1,114	..	..	..	934	1	*1·07*	14·99
Natal . .	10,043	40	*3 98*	17·43	9,824	24	*2·44*	10·0	9,409	21	*2·23*	8·50
New Zealand .	4,599	16	*3·47*	7·28	4,290	14	*3·26*	6·77	4,328	9	*2·08*	4·13
Orange River .	1,574	..	..	..	1,574	4	*2·54*	9·28	1.608	1	*·62*	2·13
Transvaal .	8,795	31	*3·52*	8·73	8,830	20	*2·26*	5·15	9.251	28	*3·03*	6·59
British Empire except India.	**1,105,285**	**1,991**	**1·80**	**6·77**	**1,123,159**	**1,372**	**1·22**	**4·55**	**1,146,853**	**1,429**	**1·25**	**4·85**
India . .	116,081	177	*1·52*	14·69	116,155	175	*1·50*	13·76	132,567	174	*1·31*	11·83

(*a*) Excluding Tasmania.
(*b*) Represents British Columbia, Nova Scotia and Alberta.

A comparison of the accident returns for India with those of other parts of the British Empire brings out the fact that, while our death-rate is low per thousand employed, it appears less favourable when we consider the lives lost in raising a million tons of coal. This is due obviously to our low output per person employed. During the past five years we have lost by accidents on an average 12·8 lives per million tons of coal raised, while for the British Empire the loss is about half this rate. Still, it is perhaps not unfair to judge the risks incurred in an industry by the relation between the loss of life and the numbers who secure a comfortable and, under Indian conditions, a fairly happy livelihood. On the whole one cannot say that the life of the Indian collier, as compared with the collier of other countries, is an unhappy one, or that his occupation is specially 'dangerous.'

Diamonds.

Distribution in India.

Notwithstanding the reputation (stretching back even as far as Ptolemy in the European, and further in the Hindu, classics) which India has had as a diamond-producing country, the output of to-day is very small and comparatively unimportant. The places which, according to accounts, have been most productive in the past form three great groups, each in association with the old unfossiliferous rocks of probable pre-Cambrian age, now known as the Purana group, and distinguished locally as the Cuddapah and Kurnool systems in South India, and as the Vindhyan system in the northern part of the Peninsula.

Southern group of occurrences.

The southern of the three groups of diamond-occurrences includes localities, with apparently authentic records, in the districts of Cuddapah, Anantapur, Bellary, Kurnool, Kistna, and Godavari. Loose stones have been picked up on the surface of the ground, found in deposits of alluvium and in workings that have been undertaken in the so-called Banaganpalle stage of the Kurnool series of strata.

Eastern group of occurrences.

In the second group of occurrences, in the Mahanadi valley, the stones have been found in the alluvium of the Sambalpur and Chanda districts, but, though strata similar to those of the Vindhyans and Kurnools are known in this area, no diamonds have been found in these older rocks.

Central Indian occurrences.

The third group of occurrences occupies a tract some sixty miles long by ten miles wide, with the Vindhyan conglomerates near Panna as the centre. The diamond-mining industry still persists in this area, both in the old conglomerate of Vindhyan age, and in the alluvium derived therefrom. The States in which diamonds are found are Panna, Charkhari, Bijawar, Ajaigarh, Kothi, Pathar Kachhar, Baraunda, and Chobepur.

The following scale of strata will give an idea of the position of the diamondiferous beds with reference to the Upper Vindhyan rocks exposed in the Central Indian area :—

BHANDER SERIES . . .	Upper Bhander sandstone. Sirbu shales. Lower Bhander sandstone. Bhander limestone. Ganurgarh shale.

Diamondiferous horizon.

REWA SERIES	Upper Rewa sandstone. Jhiri shales. Lower Rewa sandstone. Panna shales.

Diamondiferous horizon.

KAIMUR SERIES . . .	Upper Kaimur sandstone. Kaimur conglomerate. Bijaigarh shale. Lower Kaimur sandstone.

The following is a summary of the principal results of a study, by Mr. E. Vredenburg,[1] of the diamond-fields of Central India :— In the neighbourhood of Panna the principal diamond-bearing stratum is a thin layer of conglomerate, locally known as 'mudda' lying between the Upper Kaimur sandstone and the Panna shales. The conglomerate is seldom thicker than two feet and does not form a continuous bed. Further east, in the neighbourhood of Itwa, the diamondiferous conglomerate does not rest directly on the Kaimur sandstone, but is separated from it by a 20-25-foot bed of shales and limestone. Another diamondiferous conglomerate

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 261—314, (1906).

occurs above the Rewa sandstones and under the Bhander series. This conglomerate differs from that below the Rewa series in the abundance of pebbles of vein quartz, instead of the different varieties of jaspar found so commonly in the main diamondiferous conglomerate near Panna.

The diamonds in these conglomerates, like the associated large pebbles of lighter rocks, are derived from older rocks, and the original home of the gem is still unknown, though a precise recognition of the associated pebbles will gradually indicate the direction in which the mother-rock once occurred and possibly still exists. The most characteristic pebbles in the diamondiferous conglomerates are the jasper-pebbles derived from the Bijawar formation and the vein quartz similar to that traversing the Bundelkhand granites, the latter being especially abundant in the conglomerate lying above the Rewa sandstone.

Besides the diamonds lying still embedded in the conglomerates others are found in the neighbouring detritus derived from the disintegration of the Vindhyan beds. The workings are developed accordingly—some with a view to the removal of the undisturbed conglomerate, and others with the intention of recovering the diamonds included in the more recently distributed detritus.

The undisturbed conglomerate is often covered by considerable thicknesses of younger Vindhyan rocks, and is reached by workings which are often, but not always, deep. These may be called 'direct workings.' In other places the overlying younger rocks have been removed by weather agents, and the conglomerate thus exposed at the surface is available for 'shallow workings.' In the detritus removed from the original conglomerate and deposited in river-valleys the diamonds may be reached by superficial, shallow, or comparatively deep workings, and they may be all spoken of conveniently as 'alluvial workings.'

Production.

The figures returned for diamonds relate to the production in the Central Indian States of Charkhari and Ajaigarh, with the addition of Bijawar and Baraunda in 1913; and to the Karnul district and Banganapalle State in the Madras Presidency. The production during the five years under review is shown in table 36, the average for Central India being 45·94 carats worth £853, as compared with 306·71 carats worth £2,799 during the previous five years.

TABLE 36.—*Production of Diamonds in Central India and Madras during the years 1909 to 1913.*

YEAR.	CENTRAL INDIA.			MADRAS.		
	Quantity.	*Value.*	Daily labour.	Quantity.	*Value.*	Daily labour.
	Carats.	£	Persons.	Carats.	£	Persons.
1909 . .	35·98	*1,042*	589	111·37	*47*	482
1910 . .	62·24	*577*	546	15·5*	*13*	128
1911 . .	44·21	*475*	486	8·75*	*3*	50
1912 . .	8·57	*400*	699	19·17	*11*	24
1913 . .	78·70	*1,769*	661	37	*22*	18
Average .	*45·94*	*853*	*596*	*38·36*	*19*	*140*

* Value 2·5 carats in 1910 and 5·75 carats in 1911, recovered in Banganapalle, not returned.

Although no official returns are available, private but unconfirmed reports indicate that every year a certain number of valuable diamonds are picked up after showers of rain in the neighbourhood of Wajra Karur in the Anantapur district of the Madras Presidency. Several of the stones recovered during the period under review were of considerable size, the largest, it is said, weighing 57 carats.

During 1910-12, Mr. A. Ghose prospected a concession at Viraypalle in the Karnul district. The bed of diamondiferous conglomerate was found to vary between 3 inches and 2 feet in thickness and to yield from $\frac{1}{5}$ to $\frac{1}{2}$ carat of diamond from each load of 16 cubic feet, most of the diamonds obtained being perfect crystals of fine quality and free from flaws.

Gold.[1]

Comparison with other countries.

The average annual production of gold in the world during the five years 1909 to 1913 is valued at nearly 95 millions sterling. Thus India, with an average annual production of £2,242,305 (from table 39) during the same period, contributed only 2·37 per cent. of the

[1] A general account of the gold occurrences of India and Burma is given in Dr. Maclaren's 'Gold,' pp. 238—270, (1908). Considerable use has been made of this in preparing this article.

total. During the four years 1904 to 1907 India occupied the seventh position amongst the leading gold-producing countries of the world; but in 1908 it fell to the eighth position, where it still remained in 1913 (see table 37).

TABLE 37.—*Values of the Gold produced by the Chief Gold-producing Countries during 1913*

COUNTRIES.	Value.
	£
Transvaal	37,348,837
United States	18,131,627
Australasia	10,828,836
Russia	4,558,316
Mexico	4,209,446
Canada	3,329,801
Rhodesia	2,861,536
India	2,291,917
West Africa	1,611,205
Other Countries	7,827,413
TOTAL	92,998,932

The following table shows the position of India amongst the principal gold-producing colonies and dependencies of the British Empire:—

TABLE 38.—*Relative Contributions of the Principal Gold-producing Colonies and Dependencies of the British Empire.*[1]

——	1909.	1910.	1911.	1912.	1913.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Transvaal	57·3	59·6	62·5	64·9	63·3
Australia	23·3	21·5	18·8	16·5	15·8
Rhodesia	4·9	4·8	4·7	4·5	4·8
Canada	3·6	3·9	3·6	4·3	5·6
India	4·1	4·1	3·9	3·8	4·2
New Zealand	3·7	3·5	3·4	2·2	2·4

[1] Figures for 1909-12 taken from Parliamentary Blue-books; those for 1913 from *The Mineral Industry.*

Provincial production.

Table 39 shows the provincial production for India, during the five years under review. In 1904 no less than 98·2 per cent. (by value) of the Indian output was returned by Mysore, and 1·7 per cent. by the Nizam's Dominions, leaving only 0·1 per cent. as the produce of districts directly under British administration. By 1908, owing to the development of reef mining in Dharwar and of dredging in Myitkyina, the proportion derived from districts directly under British administration had risen to 2·7 per cent.; and, of the remainder, 94·4 per cent. came from Mysore and 2·9 per cent. from the Nizam's Dominions. During the period now under review the proportion of Mysore fell to 93·8, while that of the Nizam's Dominions rose to 3·37. The Dharwar output dwindled to nothing, but its place was more than filled by the new Anantapur field in the Madras Presidency. The output at Myitkyina from the Irrawaddy gravels was only 0·9 per cent. of the Indian total.

Vein gold : development of the Kolar field.

The produce of the Mysore State is solely derived from the Kolar district, and from a single vein or reef in that district—a reef averaging only some four feet in thickness, and payably auriferous for a distance of little more than four miles. As has been the case with all other known auriferous deposits in Peninsular India, the attention of Europeans was directed to this vein by the numerous old native workings along its strike. During the Wynaad gold 'boom' of 1878-82, several companies with huge capitals were floated to work portions of a concession over the Kolar field. Of the capital subscribed the greater portion was devoted to purchase money, and comparatively little was left for working capital. The features of the auriferous deposits were not at first grasped, and much money was wasted in mining in barren ground and amidst ancient workings, which were eventually found to reach to a depth of 300 feet. All the companies floated with such extravagant hopes in 1881-82 were moribund in 1885, and it was only a dying effort of the Mysore Company in that year that disclosed the great richness of the reef and incidentally the dis position of the auriferous chutes.

By 1887 the adjacent companies had resumed operations, and from that time up till 1905 the history of the field was one of uninterrupted progress and success. During the years 1906-08 there was a fall in the output owing to zones of lower grade ore having

TABLE 39.—*Quantity and Value of the Gold produced in India during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Ounces.	£	Ounces.	£	Ounces.	£	Ounces.	£	Ounces.	£
Bombay—Dharwar .	5,616	*21,331*	737	*2,590*	2,993	*10,449*	..	..	..	..
Burma—Myitkyina .	8,445	*32,730*	5,972·24	*22,930*	6,390·38	*24,269*	4,994·77	*18,931*	5,329·77	*20,412*
Other districts (Upper Chindwin, Katha, etc.).	44	*135*	24·71	*119*	22·28	*110*	73·38	*406*	63·76	*355*
Hyderabad .	15,241	*57,416*	15,762·24	*59,394*	13,726·4	*52,070*	16,993	*64,980*	20,012·4	*77,228*
Kashmir .	4	*15*	236	*944**	..	..	..	..	..	..
Madras . .	..	..	2,332	*10,120*	5,284	*20,835*	7,269	*28,499*	11,019	*43,194*
Mysore . .	545,309	*2,092,605*	547,746	*2,105,944*	555,011	*2,129,873*	561,065	*2,158,362*	559,197·98	*2,150,194*
Punjab . .	154	*621*	106	*432*	134·62	*518*	147·52	*583*	134	*517*
United Provinces.	3	*13*	3·75	*13*	5·5	*19*	12·25	*45*	4·2	*17*
TOTAL .	**574,816**	*2,204,866*	**572,919·94**	*2,202,486*	**583,567·18**	**2,238,143**	**590,554·92**	*2,271,806*	**595,761·11**	*2,291,917*

* Value estimated at £4 an ounce.

been reached; the grade subsequently improved locally at greater depth and it was hoped that this improvement would extend to all the deep mines. It is contended, however, by some mining engineers of considerable experience that as a general rule the grade of an ore does not improve in depth below certain limits, and T. A. Rickard [1] quotes figures to show that the Kolar ores have become poorer at great depths; the figures, which are given below, are said to represent the yield in pennyweights of fine gold per short ton of the four chief mines in the years 1899 and 1913 respectively:

—	1899.	1913.
Mysore	27·68	14·29
Champion Reef	26·41	10·92
Nundydroog	19·60	15·95
Ooregum	14·04	13·92

The deepest mines are Champion Reef and Ooregum, which have each reached a depth of considerably over 4,000 feet measured vertically.

Neither mining nor milling offers any serious obstacles on this field. With the former the necessity for heavy timbering and filling to keep the roadways open is perhaps the most serious. But of late years considerable trouble and uneasiness has been caused by air blasts and quakes, especially in the Champion Reef and Ooregum mines.[2] The ore is not refractory, and yields its gold to a simple combination of amalgamation and cyaniding.

During the five years under review the annual tonnage crushed gradually rose from 739,358 tons in 1909 to 809,307 tons in 1913. (These figures, returned by the Chief Inspector of Mines for Mysore, are in short tons.)

In 1905 the gold yield reached a maximum of £2,373,457, the largest ever recorded in the history of the field. Since then there has been some fluctuation in the output, although only within comparatively narrow limits, the value of the output in 1913 being

[1] 'Persistence of Ore in Depth,' *Inst. Min. Metallurgy, Bull.* No. 122, (1914).

[2] W. F. Smeeth, 'Air Blasts and Quakes on the Kolar Gold Field,' *Bull.* No. 2, *Mysore Geol. Dept.*, (1904).

£2,150,194. For the five years under review the value of gold extracted was £10,636,739, which is less by over £330,000 than the value for the preceding five years. In 1905 the dividends paid reached their maximum value, £1,066,615, for the whole period of the industry, there was then a marked annual decline to £582,488 in 1908, since when they have again risen steadily to over £750,000 in 1913. The total dividends paid during the five years under review were £3,524,640 as compared with £4,217,836 paid during the previous five years.

During the period under review dividends have been paid only by four companies, situated on the line of the Champion Reef—the Mysore, Champion Reef, Ooregum, and Nundydroog—Balaghat having ceased to pay dividends since 1907. A considerable amount of exploratory and mining work has been done by other companies on the Kolar field and elsewhere in Mysore, but hitherto without profitable result, although in several cases ore has been milled and gold won. The companies that have produced gold during the quinquennium, but have not paid dividends, are Balaghat (1908-13), Mysore West (1909-10), and Mysore Wynaad (1909-10). The following companies worked but produced no gold: The New Kempinkote Gold Field, Ltd., The New Shimoga Gold Fields, Ltd., and The Nanjangud Gold Field, Ltd.[1]

An important improvement scheme, making for the reduction of working expenses, and consequently for the prolongation of the life of the Kolar field, is the introduction of electric power from the Cauvery falls. This work was completed about the middle of 1902, and was designed for the conveyance of 4,000 H.P. over a double line 92 miles long. Since then, the generating plant has been increased from time to time and in 1913 supplied 67 motors aggregating 8,707 H.P. This supply is continuous, except in years of drought, when there may be short stoppages during the hot weather owing to a scarcity of water in the river Cauvery.

In order to supply power for electric lighting and the driving of motors used intermittently, a company, called the Kolar Mines Power Station, Ltd., was formed in 1903, the electricity to be generated by steam power. The company began to supply power at the end of 1904, and in 1912 supplied altogether, for intermittent power as well as for power for hoisting and lifting, 4,786,036 Board of Trade units.

[1] Figures available only to 1912.

The completion of the scheme of water-supply from the Bethamangala Tank, some 6 miles from the field, undertaken by the Mysore Government, now ensures the mines a supply of filtered water sufficient for all purposes.

Table 40 shows the various statistics of production for the Kolar field both for the period under review and for the previous quinquennium.

TABLE 40.—*Statistics of Production in the Kolar Gold-field.*

—	Tonnage crushed.	Value of gold extracted.	Dividends paid.	Royalty paid.
1904	730,841	2,323,194	1,041,939	115,081
1905	781,281	2,373,457	1,066,615	117,081
1906 (a)	744,165	2,170,470	866,779	107,427
1907 (a)	733,809	2,051,773	660,015	101,157
1908	720,808	2,050,917	582,488	101,861
TOTALS for 1904-1908	**3,710,904**	**10,969,811**	**4,217,836**	**542,607**
1909	739,358	2,092,177	636,182	103,279
1910	783,088	2,106,133	658,584	117,803
1911	795,013	2,129,873	726,248	124,867
1912	808,507	2,158,362	749,398	126,653
1913	809,307	2,150,194	748,395	126,220
TOTALS for 1909-1913	**3,935,273**	**10,636,739**	**3,518,807**	**598,822**

(*a*) This includes 711 tons of ore crushed on the Nanjangud field in 1906 with production of 95 ozs. bar gold, and 464 tons in 1907 with production of gold worth £530.

Total value of gold produced from 1882 to 1913 inclusive	£40,293,750
" " " dividends paid " " " "	£16,024,191
Royalty paid to Mysore Government from 1882 to 1913 inclusive	£2,067,923

The work of the field is carried on by Europeans, Anglo-Indians, and Indians, in the following proportions, calculated from the number employed during the year 1912, the latest for which figures are available :—

Europeans (including Italian miners)	1·9
Anglo-Indians	1·3
Indians : men	90·5
Indians : women (employed only on the surface) . . .	5·6
Indians : children (under 14 years : employed only on the surface)	0·7

The following table indicates the risks attendant on mining in the Mysore State :—

TABLE 41.—*Showing Fatal Accidents in Mysore Mines for the years 1909 to 1913.*

YEAR.	Number of persons employed.	*Death-rate per 1,000 employed.*	Death-rate per £100,000 worth of gold obtained.
1909	28,873	*3·64*	5·01
1910	27,205	*2·72*	3·51
1911	26,258	*3·35*	4·13
1912	26,508	*3·36*	4·12
1913	25,571	*4·38*	5·21
Average .	*26,883*	*3·41*	*4·42*

Hyderabad (Nizam's Dominions).

The only gold-field in India besides Kolar from which there has been a continuous production of vein gold during the quinquennium is the Hutti field, situated on the Maski band of Dharwar schists in the Lingsagar district of the Nizam's Dominions (Hyderabad). The only company operating on this field is the Hutti (Nizam's) Gold Mines, Ltd. It is an offshoot of the Hyderabad (Deccan) Company and was floated in 1901. Crushing with 10 head of stamps was commenced in 1903, with a production of 3,809 ozs. of gold in that year. Since then the number of stamps has been increased to

30. One of the shafts had reached a depth of over 2,000 feet by the end of 1913. Dividends have been paid regularly since 1904. Table 42 gives the production statistics of this mine; it will be seen that the average amount of gold extracted during the period under review has been 8·6 dwts., worth £2·046, per ton of quartz crushed.

TABLE 42.—*Statistics of Production at the Hutti Mine.*

YEAR.	Tonnage crushed.	*Bar gold produced.*	Value of gold extracted.
	Tons.	*Ozs.*	£
1909	33,466	*15,241*	57,416
1910	39,690	*15,762·2*	59,394
1911	30,750	*13,726·4*	52,070
1912	21,883	*16,993*	64,980
1913	26,172	*20,012·4*	77,228
TOTAL .	**151,961**	*81,735*	**311,088**

In 1905 another company, known as the Topuldodi (Nizam's) Gold Mines, Ltd., with a capital of £90,000 was formed to take over from the Hutti Company an option held on the Topuldodi block in the Raichur district of the Nizam's Dominions. During 1908, 2,132 ozs. of gold, worth £8,319, were produced. But as the ore developed in the mine proved to be of very low grade, the mine was closed down, and its assets transferred to the Hutti Company.

The Dharwar Gold-field.

A third Indian field on which work was actively prosecuted during the earlier part of the quinquennium is the Dharwar field, situated on the Gadag band of Dharwar schists, partly in the Dharwar district and partly in the Sangli State, both of which lie in the Bombay Presidency. In spite of the expenditure of much capital in very thorough development operations, the reefs were found too poor to work and the mines were abandoned in 1911.

Anantapur.

In 1902 Mr. E. W. Wetherell, of the Mysore Geological Department, discovered a previously unknown belt of Dharwar schists stretching in a north and south direction for some 32 miles through the Anantapur district of Madras, but just touching the north-east corner of the Pavagada taluk of the Tumkur district of Mysore. Several large quartz reefs occur in this belt, and near the village of Ramgiri old gold workings were found. The gold occurs in quartz veins principally in chloritic and argillaceous schists. A company, called the Anantapur Gold Field, Ltd., was formed in 1905. In 1908 it transferred a portion of its holdings (the Buruju block) to a new company, the North Anantapur Gold Mines, Ltd., and other portions (South Jibutil block and, subsequently, North Jibutil block) under option to the Nundydroog Company of Mysore. The option was exercised and the Jibutil Gold Mines of Anantapur, Ltd., was formed to take over the properties from the Anantapur Gold Field, Ltd., on payment of £5,000 in cash and 160,000 fully paid shares, of which 20,000 went to the Nundydroog Company. The North Anantapur Gold Mines, Ltd., have carried on vigorous development work, having sunk five shafts up to the year 1913. The capacity of the mill is 30 stamps treating 3,000 tons monthly.

The mines, which are situated in the Dharmavaram taluq of Anantapur district, produced 2,532 ounces in 1910. Since then the output has risen steadily to over 11,000 ounces in the last year of the period under review.

The Nilgiris.

The Nilgiris, after many vicissitudes, have ceased to be a mining area; but some native workers are reported to be making a living by roughly treating the waste heaps, from which they extract a small quantity of gold.

Gold in sulphide lodes.

Besides occurring in the free state in quartz veins, as in all the areas noticed above, gold is sometimes found in sulphide loads enclosed in the sulphide minerals. Thus gold occurs in Sikkim among the mixed sulphide lodes (chalcopyrite, pyrite, pyrrhotite, blende, etc.), and in the copper-bearing lodes of Sleemanabad in the Jubbulpore district of the Central Provinces. Assays in the latter case have occasionally shown amounts as high as 15 dwts. per ton.

Alluvial gold.

Alluvial gold-washing is carried on in many places in British India, but from the fact that the washers invariably combine this pursuit with other occupations, and because the individual return is exceedingly small and is locally absorbed for jewellery, complete returns are not available. These, so far as they go, give little hope of the discovery of rich alluvial deposits in Peninsular India, or indeed in any part of India affected by the monsoon rains and dependent on them alone for the supply of the rivers. For concentration of gold a comparatively equable current is essential—a condition rarely obtainable in the gravel river beds of India, where alone gold would be found, for these are almost dry in the cold weather and roaring torrents in the rains. The greater possibilities of dredging on the Irrawaddy appear to arise from the fact that the waters of that river are derived from ranges where, even in the cold weather, there is a heavy rainfall.

Assam.

In Upper Assam [1] tributaries, such as the Subansiri, that flow from the north into the Brahmaputra carry small quantities of gold. One small bar near the mouth of the Subansiri gorge was found to contain more than a dwt. per cubic yard; but the quantity of gravel available was very small. It is probable that some of the gold of this region is derived, immediately, from the Tipam (Siwalik) sandstones, and that the source of the gold in the Lohit branch of the Brahmaputra is to be sought in the metamorphic rocks of the Miju ranges.

Chota Nagpur.

In the Chota Nagpur division of Bihar and Orissa, alluvial gold is found widely distributed, but the gold washing is of most importance in the Singhbhum and Manbhum districts, and is chiefly confined to the valley of the Subarnarekha ('golden-streaked') river and its tributaries. The average earnings amount to only As. 1-6 to 2 a day.

The result of the work of Dr. Maclaren [2] and of other members of the Geological Survey was to show that nowhere in Chota Nagpur had gold deposits—either alluvial or vein—been found worth working on European lines. Latterly, however, an attempt has been made to revive interest in that area and a company has been

[1] Maclaren, *Rec. Geol. Surv. Ind.*, XXXI, pp. 179—232, (1904).
[2] *Rec. Geol. Surv. Ind.*, XXXI, pp. 59—91, (1904).

promoted to work gold mines in Dhalbhum State. The information so far published, however, is not very precise. It is believed that systematic prospecting operations are now being undertaken with a view to ascertaining the real possibilities of the area.

Burma : native gold-washing.

The native gold-washing industry is carried on from year to year in several districts in Burma, usually by only a few people in each district; the number so engaged varies from year to year partly in accordance with the character of the seasons. No accurate figures of production are available. In 1908 gold was washed in the following districts:—Bhamo, Katha, Lower Chindwin, Myitkyina, Pakokku, Prome, Shwebo, Toungoo, and Upper Chindwin. The returns for 1913 show only a production of 63·76 ounces, derived from Katha, Pakokku, and Upper Chindwin.

Burma : gold-dredging ; the Irrawaddy.

The gold-dredging on the upper reaches of the Irrawaddy is largely due to the enterprise of Mr. W. R. Moore who (in association with Captain J. Terndrup) was granted in 1901 a five-years' license for dredging within the bed of the river for a stretch of some 120 miles from the confluence above Myitkyina to the mouth of the Taiping above Bhamo. In 1904 the license was extended for a period of thirty years and restricted to about 88 miles of the river from Sinbo to the confluence, while sanction was given at the same time to transfer the concession to the Burma Gold Dredging Company, which was registered at Rangoon in 1903. In 1907 permission was given to alter the limits of the concession by exchanging 15 miles of the lower end for 10 miles along the 'N Maikha and 5 miles along the Mali-kha. Application was subsequently made for a further exchange of the Irrawaddy part of the concession for 15 miles along the eastern river, 'N Maikha. This company was liquidated in 1911, and a new company formed, called the Burma Gold Dredging Company, 1911, Ltd.

For the greater part of the period five dredges were at work, but the results did not come up to expectations. Expenses, however, were recently cut down considerably by the substitution of Kachin for Australian skilled labour. But the output is still considerably below that of 1909; this is attributed to the poor quality of the wash remaining to be worked in the bed of the river. The annual outturn for the period 1909-13 is shown in table 41.

TABLE 43.—*Alluvial Gold won by the Burma Gold Dredging Company, 1911, Ltd., during 1909-13.*

YEAR.	Quantity.	*Value.*
	Ounces.	£
1909	9,041	*34,657*
1910	5,180	*19,856*
1911	5,919	*22,689*
1912	4,925	*18,715*
1913	5,058	*19,387*
Average	*6,024·6*	*23,061*

The gold-bearing alluvium is coarse gravel with the gold disseminated fairly uniformly. The average value of the gravel seems to be about 3 grains (6 annas) per cubic yard. Small quantities of platinum and platinoid metals are recovered with the gold. The average annual production of gold (see table 39) has risen from a little under 2,000 oz. in the last quinquennium to 6,226 oz. in the period under review.

The Chindwin.

The alluvial stretches of the Chindwin river have been found to contain gold at many points, but systematic prospecting has in most cases shown them to be valueless as dredging propositions, although they are a source of income to the native gold washers.[1] A concession for 180 miles of the Lower Chindwin river, stretching from Minsin to Homalin, was granted about 1903 to the Burma Mines Development and Agency, Ltd., and in 1905 transferred to the Mandalay Gold Dredging Company, Ltd. A dredger was obtained, but became stranded while being towed up the Chindwin river, and no further work was attempted.

The Uyu, a tributary of the Upper Chindwin, has also been prospected for alluvial gold, but with little success so far.

[1] H. S. Bion, *Rec. Geol. Surv. Ind.*, XLIII, p. 341, (1913).

The Namma.

In 1905 the Namma Gold Dredging Company, Ltd., with a capital of £70,000 (£55,000 issued, of which £30,000 went to vendors) was floated in London to work two stretches of the Namma river, a tributary of the Salwin, in the Shan States. A careful preliminary investigation had indicated the existence of approximately 40,000,000 cubic yards of gravel averaging 5·43 grains of fine gold per cubic yard. A steam dredger was purchased and floated in a paddock on the Upper Namma, and it was then found that the deposit was unfitted for this mode of exploitation. It consists of gravel and boulders embedded in a stiff clay, hardened by calcareous tufa derived from the limestone forming the sides of the valley, and is therefore not sufficiently loose to enable the buckets of the dredger to excavate it. The venture, therefore, ended in failure.

The alluvial gold deposits of Loi Twang in the Shan States, worked by native washers, have been examined in detail by Mr. T. D. LaTouche and found to be of no commercial value.[1] Alluvial deposits examined by Mr. J. Coggin Brown, in Mong Long, Hsipaw State, were also found to be too poor generally to be worth exploitation, although small patches were found to contain occasionally over 9 grains of gold to the cubic yard.[2]

Other Burmese rivers to which attention has been directed by European prospectors, without any tangible results so far, are the More Chaung, Taiping, and Shweli, tributaries of the Irrawaddy; the Upper Chindwin; the Salwin; and the streams of Tavoy, where gold has been found associated with tinstone.

The Central Provinces.

Alluvial gold occurs in the sands and gravels of many of the rivers and streams of the Central Provinces, particularly in those that drain down from or run over areas where the ancient crystalline and metamorphic rocks crop out. According to an "Industrial Monograph on Gold and Silverware of the Central Provinces," by H. Nunn, I.C.S., published at Allahabad in 1904, which contains also the best account yet published of the native gold-washing industry of that province, gold-washing has been carried on at various times in the following districts:—Balaghat, Bhandara, Bilaspur, Chanda, Jubbulpore, Mandla, Nagpur, Raipur, Sambalpur, and Seoni. From the report quoted it appears that in addition to the washers of

[1] *Rec. Geol. Surv. Ind.*, XXXV, pp. 102—113, (1907).
[2] *Rec. Geol, Surv. Ind.*, XLII, p. 37, (1912).

auriferous sands there are people engaged in a cognate industry, consisting of the extraction of the gold and silver particles, called in England 'lemel,' from the dust of a *sunar's* shop and furnace by a two-fold process, first of actual winnowing, and then of washing in a river. The resultant gold is treated by refining processes. The persons practising this 'lemel' washing, which is recorded for the Balaghat, Bilaspur, and Hoshangabad districts, are Mahomedans, and it is desirable to distinguish their occupation from that of the gold-washers proper, although there is doubtless at times a certain overlapping of the two occupations. The gold-washers are variously known in different parts of the province as *jharas, jharias, sonjharas, sonjhirias,* and *sonzaras.* The report cited gives a full account of the methods of washing and treating the gold as practised in the Tirora tahsil of the Bhandara district. The whole gold industry of the Central Provinces, however, is small and no reliable figures for output are available. It is not likely that more than 200 ounces are won annually.

Kashmir.

Washing for alluvial gold has been practised along the valley of the Indus in the Baltistan and Ladakh divisions of Jammu and Kashmir State. In Kargil and Skardo, Baltistan, the washing of ancient gravel deposits has been carried out on quite an extensive scale, actual mining operations having been undertaken to excavate the gold-bearing bands in the old river terraces in the Dras valley. The production of gold from Kashmir in 1910 was returned as 236 oz., since when no returns have been received. A small quantity of alluvial gold is said to have been obtained formerly by Tibetans from sub-recent gravels on the Para river on the border between Rupshu and the Tibetan Province of To-tzo.[1]

Punjab.

Gold-washing is carried on also in some of the Punjab rivers especially the Indus, and the production for the quinquennium totals 676 oz., giving an average annual figure of 135 oz. In 1908 a prospecting license for dredging over a length of 48 miles of the Indus, in the Attock district of the Punjab and the Peshawar and Hazara districts of the North-West Frontier Province, was granted to Lieutenant M. Snee, who is believed subsequently to have given an option over his concession to the Kashmir Mineral Company, Ltd.; no development, however, appears to have been attempted.

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).

In the United Provinces the industry was reported in 1904 as employing about 100 workers in the Nagina tahsil of Bijnor district, and smaller numbers in Garhwal and Naini Tal. The total reported production during the quinquennium was 29 oz.

United Provinces.

Graphite.

Mode of occurrence.

Graphite occurs in small quantities in various parts of India—in the so-called khondalite series of rocks in the Vizagapatam hill-tracts and adjoining Chhattisgarh Feudatory States, in a corresponding series of rocks in Coorg, in the Godavari district of the Madras Presidency, in the Ruby Mines district in Upper Burma, and in Travancore. It has also been discovered in Sikkim, where a graphite vein, averaging about 13 inches in thickness, was found during the prospecting operations conducted by Messrs. Burn and Co. at about half a mile to the north of the road from Tsuntang and Lachen. The quality of the mineral is said to be good, large bulk samples having given a return of 93 per cent. of graphite. Other veins of graphite are known to occur in the area, but have not been examined in detail.[1]

The graphite deposits of Travancore occur under conditions similar to those of Ceylon, which is but a continuation of the charnockite series and associated rocks of South India. The Ceylon graphite has been made the subject of an elaborate study by E. Weinschenk, who regards it as of igneous origin,[2] a conclusion in agreement with its occurrence in South India.[3] Small quantities of graphite have been extracted in Godavari and Vizagapatam, but practically the whole of the Indian output came from Travancore, where the average output used to be about 13,000 tons annually. Owing to difficulty of working at increased depths, however, the mines were no longer found to pay and were shut down in 1912.

Production.

[1] According to a report by C. Wilkinson, communicated by the late Mr. A. Whyte of Raniganj.

[2] Die Graphitlagerstätten der Insel Ceylon. *Abhand., d. k. Bayer., Akad.*, 1901, xxi, pp. 279—335.

[3] Holland. The Charnockite Series, *Mem. Geol. Surv. Ind.*, XXVIII, p. 126, (1900); and the Sivamalai Series, *Mem. Geol. Surv. Ind.*, XXX, p. 174, (1901).

TABLE 44.—*Production of Graphite during the years 1909 to 1911.*

—	1909.		1910.		1911.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£
Travancore .	3,132	*12,529*	3,992	*19,962*	3,993	*15,972*
Vizagapatam .	..	..	259	*517*	54	*108*
TOTAL .	**3,132**	*12,529*	**4,251**	*20,479*	**4,047**	*16,080*

Iron.

Production.

Bengal and Bihar and Orissa are the only provinces in India in which iron-ore is mined for smelting by European methods. Table 45 shows the annual production in those provinces during the five years under review. On comparing this with the corresponding table of the previous Review it will be seen that the production suddenly increased enormously in 1911 by nearly 300,000 tons, the output rising from 42,653 tons in the preceding year to 342,342 tons in 1911. This was due to the operations of the Tata Iron and Steel Co., whose works at Sakchi were completed towards the end of that year; large quantities of iron-ore were therefore raised from their Gurumaishini deposits in Mayurbhanj State with a view to bringing the blast furnaces into operation. From 1911 onwards the output of ore has been of the same order of magnitude. It will be noticed that the value returned for the ore has fallen from an average of 3·26 shillings per ton to 1·85 shillings. This figure is of course merely nominal, there being no market for ore in the country and no export trade. For the total production for each year see table 45.

General character of the iron-smelting industry.

Iron smelting was at one time a widespread industry in India, and there is hardly a district away from the great alluvial tracts of the Indus, Ganges, and Brahmaputra, in which slag-heaps are not found. For the primitive iron-smelter finds no difficulty in obtaining sufficient supplies of ore from deposits

that no European iron-master would regard as worth his serious consideration. Sometimes he will break up small friable bits of quartz-iron-ore schist, concentrating the ore by winnowing the crushed materials in the wind or by washing in a stream. Sometimes he is content with ferruginous laterites, or even with the small granules formed by the concentration of the rusty cement in ancient sandstones. In ancient times the people of India seem to have acquired a fame for metallurgical skill, and the reputation of the famous *wootz* steel, which was certainly made in India long before the Christian era, has probably contributed to the general impression that the country is rich in iron-ore of a high-class type. It is true that throughout the Peninsula, which is so largely occupied by ancient crystalline rocks, quartz-hematite and quartz-magnetite schists are very common in the Dharwarian system, the system of rocks that lithologically, as well as in stratigraphical relationship, corresponds approximately to the Lower Huronian of America. But most of these occurrences consist of quartz and iron-ore so intimately blended that only a highly siliceous ore of a low grade can be obtained without artificial concentration. These occurrences of quartz-iron-ore schist are so common in India that newly recorded instances are generally passed over as matters of very little immediate economic interest. During the past few years, however, distinct ore-bodies of considerable size and richness have been recognised in the Central Provinces and in the Mayurbhanj State.

Attempts to introduce European processes.

Earlier attempts to introduce European processes for the manufacture of pig-iron and steel, in India, had been such conspicuous failures that there was naturally some hesitation in reposing confidence in the project launched by Messrs. Tata, Sons and Co. Perhaps the earliest attempt to introduce European processes was due to the enthusiasm of Mr. Josiah Marshall Heath of the Madras Civil Service, who, having resigned the service of the East India Company, obtained the exclusive privilege of manufacturing iron on a large scale in the Madras Presidency. In 1830, trial works were erected at Porto Novo in the South Arcot district, and were maintained by subsequent financial assistance from the East India Company. The business was taken over in 1833 by the Porto Novo Steel and Iron Company, and additional works were started at Beypur on the Malabar Coast. Various

TABLE 45.—*Quantity and Value of Iron-ore raised during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bengal (Burdwan)	46,623	*6,751*	24,387	*3,655*	5,456	*780*	9,882	*1,350*	8,926	*1,278*
Bihar and Orissa	26,088	*6,947*	18,266	*2,963*	336,886	*27,399*	555,265	*41,737*	345,887	*34,304*
Burma	7,480	*1,995*	7,480	*1,995*	20,995	*5,599*	12,563	*3,350*	11,480	*3,061*
Central Provinces	1,935	*516*	3,637	*970*	1,944	*470*	1,768	*461*	3,774	*830*
Other Provinces and States.	1,313	*350*	818	*218*	909	*242*	746	*198*	778	*203*
Total, STATUTE TONS AND £.	**83,439**	*16,559*	**54,588**	*9,801*	**366,190**	*34,490*	**580,224**	*47,096*	**370,845**	*39,676*

TABLE 46.—*Iron-ore raised in Bengal and Bihar and Orissa during the years 1909 to 1913.*

YEAR.	Burdwan.	Singhbhum.	Manbhum.	Sambalpur.	Mayurbhanj.	TOTALS FOR BENGAL AND BIHAR AND ORISSA.		
						Quantity.	*Value.*	Value per ton.
	Tons.	Tons.	Tons.	Tons.	Tons.	**Tons.**	£	
1909	46,623	15,215	10,132	737	..	**72,711**	*13,698*	3·77
1910	24,387	17,646	..	620	..	**42,653**	*6,618*	3·10
1911	5,456	36,276	..	610	300,000	**342,342**	*28,179*	1·64
1912	9,882	83,425	..	608	471,232	**565,147**	*43,087*	1·52
1913	8,926	98,196	..	666	247,025	**354,813**	*35,582*	2·00
Average	*19,055*	*50,152*	..	*648*	*339,419 (3 years).*	*275,533*	*25,433*	*1·85*

NOTE.—Ore raised in Burdwan, Singhbhum and Manbhum is for the Barakar Iron-works. That raised in Sambalpur is smelted in native furnaces. That raised in Mayurbhanj is for the Tata Iron and Steel Co.'s works.

concessions were granted to Mr. Heath and the succeeding Iron Company, but in spite of these, the undertaking proved to be a failure. In 1853, a new Association, known as the East India Iron Company, was started with a capital of £400,000. This Company obtained various concessions from Government, and erected two blast furnaces, one in the South Arcot district, and another on the Cauvery river, in the Coimbatore district. These furnaces were stopped in 1858, whilst operations at Porto Novo ceased in 1866, and at Beypur in 1867. Other attempts to introduce European processes have been made in the Birbhum district of Chota Nagpur and at Kaladhungi in Kumaon. But the only scheme which proved to be a financial success is that now in operation near Barakar in Bengal. Even the Barakar Iron-works passed through various vicissitudes of fortune, and showed no signs of financial success until they were taken over by the present Managing Agents, Messrs. Martin & Co.

Bengal Iron and Steel Company, Barakar.

Production of pig-iron.

The Barakar Iron-works were taken over byt he present Company in 1889 and completely remodelled. There are now (1913) three blast furnaces in operation with daily productive capacity of 330 tons of pig-iron, but the output is restricted to very much less on account of the limited demand for pig-iron. During the five years under review the production of pig has been as follows :—

	Tons.
1909	38,634
1910	35,933
1911	49,183
1912	58,883
1913	59,187

The following are average analyses of the pig-iron produced :—

—	Grades 1, 2, 3.	Foundry pig, 3 and 4.
	Per cent.	Per cent.
Graphitic carbon	3·13	2·98
Combined „	0·23	0·32
Silicon	2·99	2·26
Phosphorus	1·20	1·21
Manganese	1·40	1·13
Sulphur	0·022	0·03

Castings.

The iron foundries cover an area of 104,000 square feet, and include pipe-foundries, sleeper and chair foundries, as well as arrangements for miscellaneous castings. During the five years 1909-13 the production of castings was as follows :—

	Tons.
1909	12,216
1910	7,930
1911	14,500
1912	13,857
1913	17,536

The blowing engines include two Barclay, one Galloway of 750 H.P. and one Parson's turbo of about the same horse-power. These are being superseded by two Parson's Turbo Blowers with a capacity of 43,000 cubic feet per minute at a pressure up to 10 lbs. per sq. inch.

Coke.

The coke used was formerly made mostly in open kilns, but these have now been replaced by a battery of 34 Simon-Carvès bye-product recovery ovens, to which another battery of the same size will shortly be added. When this is complete the plant will be capable of turning out about 8,000 tons of coke monthly. At present only coal tar is extracted as bye-product, but it is proposed to recover also sulphate of ammonia, and for this purpose a plant for the manufacture of sulphuric acid is being installed at the works.

Coal.

The coal supply is drawn partly from the Company's collieries near the works at Kendwa and Ramnagar and partly from the property of the associated Company owning collieries at Noonoodih in the Jherria field.

Flux.

The limestone used as flux is obtained from the Vindhyan beds at Satna in the Rewa State, and gives the following average analysis :—

	Per cent.
Calcium carbonate	90·62
Silica	6·25
Ferric oxide and alumina	1·10
Magnesium carbonate	1·86
	99·83

Iron-ore.

The site of the Barakar Iron-works was originally chosen on account of the proximity of both coal and ore supplies. The outcrop of ironstone shales between the coal-bearing Barakar and Raniganj stages stretches east and west from the works, and for many years the clay ironstone nodules obtainable from this formation formed the only supply of ore used in the blast furnaces.

The ore from this formation as recently used gave the following analysis :—

	Per cent.
Iron	43·43
Silica	16·44
Manganese	2·15
Phosphorus	0·86

Recently, magnetite and hematite have been obtained from the Manbhum and Singhbhum districts, and the production from the last-named district has, during the quinquennium, largely replaced the supplies of ore hitherto obtained near the Iron-works. Finally, the Bengal Iron and Steel Company, Limited, have now given up the use of ores obtained from the neighbourhood of Barakar and Raniganj and are now obtaining their ores exclusively from the Kolhan Estate, Singhbhum. The deposits are known as Pansira Hill and Buda Hill situated about 12 miles and 8 miles south-east of Manharpur Station, Bengal-Nagpur Railway. The total quantity of ore in these two deposits has been estimated to be about 10 million tons. The ore shows an average analysis as follows :—

	Per cent.
Iron	64·00
Silica	3·09
Manganese	·06
Phosphorus	·05

A 2′ 6″ railway line has been constructed by the Bengal Iron and Steel Company, Limited, from Manharpur to the former deposit, as also an aerial ropeway capable of 50 tons hourly for transporting the ore from the top of Pansira Hill to the Light Railway at the foot. Since the use of this ore the quality of this Company's iron has shown very considerable improvement and is now said to be superior to any imported from Europe.[1]

The following table shows the quantity of ore used during the period under review :—

TABLE 47.—*Iron-ore used at the Barakar Iron-works.*

YEAR.	Statute Tons.
1909	77,971
1910	63,795
1911	67,653
1912	95,748
1913	96,230

[1] We are indebted to Messrs. Martin & Co. of Calcutta for this information.

The average number of persons employed daily at the Barakar Iron-works, exclusive of labour employed by contractors, is as follows :—

Labour.

1909	3,411 persons.
1910	2,607 „
1911	3,582 „
1912	4,026 „
1913	5,017 „

The Tata Iron and Steel Company.

Since the issue of the last Quinquennial Review, the Tata Iron and Steel Company, Ltd., has completed the erection of its works at Sakchi and is now turning out both iron and steel.

The preliminary operations which led to the formation of this Company were inaugurated by the late Mr. J. N. Tata, and were carried on by his successors in the firm of Messrs. Tata, Sons & Co., Ltd., Bombay. According to the prospectus, the vendors receive the expenses of their preliminary operations, amounting to Rs. 5,25,000 (£35,000), *plus* Rs. 15,00,000 (£100,000) in ordinary shares, the cash paid for expenses being re-invested in shares *plus* an additional sum of Rs. 4,75,000 (£31,666). Messrs. Tata, Sons & Co. also become the Managing Agents of the Company for the first period of eighteen years on consideration of a remuneration of 5 per cent. on the annual net profits, with a minimum remuneration of Rs. 50,000 (£3,333), commencing only from the 1st July 1910.

The Company, which was registered on the 26th August 1907, with a nominal capital of Rs. 2,31,75,000 (£1,545,000), holds concessions for iron-ore in the Mayurbhanj State of Orissa, and also near Dhullee, 38 miles south of Rajnandgaon in the Raipur district of the Central Provinces, with smaller deposits in the Drug district. It also possesses a manganese-ore property near Ramrama in the Balaghat district, Central Provinces, as well as deposits of limestones near Katni, dolomite in Gangpur, magnesite and chromite in Mysore, and coal in the Jherria field.

The works are situated at Sakchi in the Singhbhum district to the north of Kalimati Railway Station, 153 miles from Calcutta, and at the junction of the Khorkai and Subarnarekha rivers, from which is drawn the water required for the works and the new town. Plate 4 shows a general plan, and Plate 5 a general view, of the works. The main elements, as will be seen from the plan, consist of coke ovens, blast furnaces and blowers, electric power and pumping plants, foundry, steel plant, gas producers, rolling mills and

bar mills, with the usual complement of machine shops, pattern shops, yards, etc. The coke-oven plant consisted in 1913 of 180 Coppée non-recovery ovens and 30 bechive ovens, producing altogether about 15,000 tons of coke monthly. This plant is being still further increased by the addition of a battery of bye-product recovery ovens, and the total output is expected to be ultimately over 800 tons a day.

There are two blast furnaces, each 19 feet in diameter and 77 feet high, with Zoelly turbo-blowers. In 1913 they had attained a maximum monthly production of nearly 15,000 tons, which, however, could not be maintained until larger supplies of coke were made available. The steel plant consists of one 300-ton gas-fired mixer, four 50-ton basic open-hearth furnaces, and three gas-fired soaking-pits. Gas is obtained from a plant of sixteen Morgan mechanical gas-producers.

The rolling mill consists of one blooming mill, with rolls 80 inches long and 33 inches in diameter, and one 28-inch two-high reversing rail-mill with three stands of rolls. These are operated by an Ehrhardt and Sehmer three-cylinder reversing engine, non-condensing, with cylinders $51\frac{3}{8}$ inches $\times$ $51\frac{3}{8}$ inches. The hot saw is placed in a separate building 300 feet from the centre of the rail mill, whence the rails are led to it by a line of rollers.

The works were completed in 1911; the first blast furnace was blown in December 1911 and the second in September 1912. The first steel furnace was tapped early in 1912.

Considerable difficulties were experienced at first in connection with the manufacture of steel; these, however, have now been overcome and the Government of India have placed a standing order with the works for 20,000 tons of steel rails annually for the Indian State railways; these rails are tested in a laboratory maintained by the Government of India at Sakchi under the supervision of a Government expert.

The output of the works up to the end of the year 1913 is shown below[1]:—

	Tons.
Pig-iron	231,925
Steel ingots	63,175
Blooms	53,015
Structural materials, beams, angles, channels and heavy rails.	34,312
Bars, angles, channels, light rails and fishplates	6,491

[1] From figures kindly furnished by Messrs. Tata, Sons & Co.

Iron-ores of Mayurbhanj State.

Although the Tata Iron and Steel Company possesses slightly richer and purer ore-bodies in the Raipur district, supplies of ore are at present drawn from the deposits in Mayurbhanj, which are nearer to the site of the works and to which the Bengal-Nagpur Railway Company has built a branch line about 45 miles in length.

The occurrence of valuable iron-ore deposits in Mayurbhanj was first noticed by P. N. Bose,[1] who mentioned the following occurrences :—

(*a*) Bamanghati sub-division—

(1) Gurumaishini Hill, over an area of 8 square miles.

(2) Near Bandgaon in Saranda-pir.

(3) Sulaipat-Badampahar range from Kondadera to Jaidhanposi, a distance of some 12 miles.

(*b*) Panchpir sub-division—

At several places from Kamdabedi and Kantikna to Thakurmunda, a distance of 25 miles.

(*c*) Mayurbhanj proper—

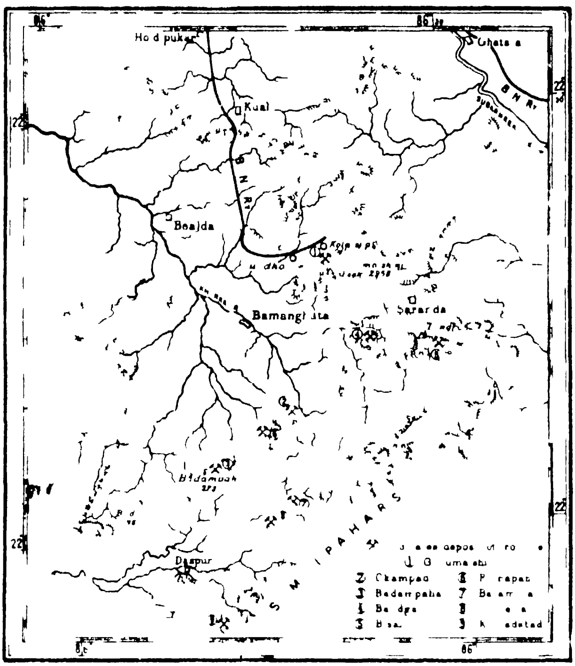
Simlipahar range, and the sub-montane tract to the east (Gurguria, Kendua, and Baldia).

Subsequently, on the possibility of these ores being suitable for the proposed iron and steel works, they were re-examined by Messrs. C. P. Perin and C. M. Weld, who arranged for detailed prospecting operations after securing prospecting rights from His Highness the Maharajah. A subsequent examination of the ground by Mr. W. Selkirk having demonstrated the existence of sufficient ore to warrant operations on a large scale, a lease was granted to the Company over 20 square miles on a royalty-scale that will work out to an average of 2·625*d.* per ton for the first thirty years and 5*d.* per ton for the next following thirty years, on an annual output of 200,000 tons of ore.

Prospecting operations determined the existence of over a dozen considerable deposits of high-grade ore in the more accessible parts of the State (see fig. 10). Of these deposits three, namely, Gurumaishini, Okampad (Sulaipat), and Badampahar, so far overshadow the others that reference will be made in detail to them alone. The chief point of interest in connection with the smaller deposits is that in every case the nature or type of occurrence is practically

[1] *Rec. Geol. Surv. Ind.*, XXXI, p. 168, (1904).

identical with the great deposits, they being miniature reproductions as it were of the latter. As the main work of the prospectors has been devoted to the first necessary problem of determining the superficial disposition of the richer ore-bodies, very little has been done so far in the way of studying the geological relations and genesis of the ores.[1]



Scale —1 inch 16 miles

FIG. 10 —*Map showing position of the Mayurbhanj iron ore deposits*

The ore-deposits have all been found to take the form of roughly lenticular leads or bodies of hematite, with small proportions of magnetite, in close association with granite on the one hand and granulitic rocks on the other These latter have been noted in the field as charnockites the term being employed, rather loosely no doubt, but probably in the main correctly, to cover types of pretty widely varying acidity. In still more intimate association with the ores than either of the foregoing were found masses of dense quartz rocks, frequently banded, and banded quartz-iron-ore

[1] We are indebted to Mr C M Weld for the observations summarised below.

rocks. These last are of the types so commonly associated with Indian iron-ores, but are here not so prominent as is usually the case. Lastly, there exists a net-work of basic dykes certainly cutting the granite and apparently cutting the iron-ores and charnockite.

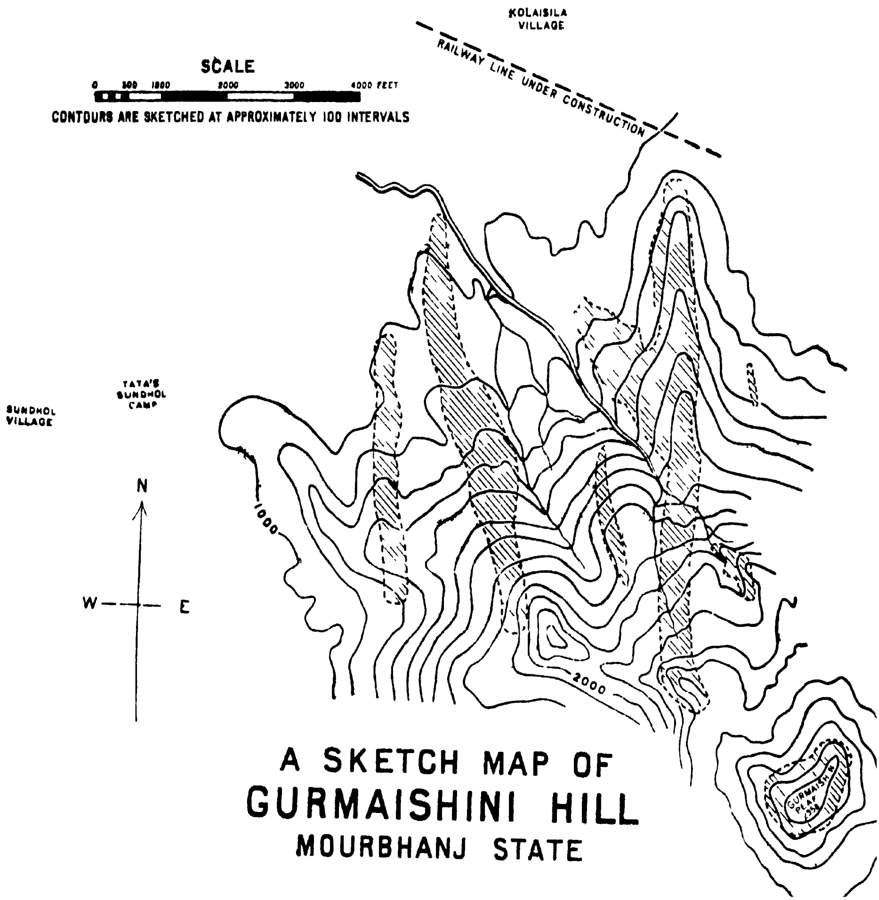


FIG. 11.

In a very broad general way the impression so far received has been that the ore-bodies occur at or near the contacts between the granite masses and the charnockites. This impression is pregnant with suggestion, but needs a great deal of verification. The

relative age of the granite and charnockite has not as yet been determined.

(1) Gurumaishini.

The Gurumaishini hill-mass, with its three prominent peaks, the highest rising to an elevation of 3,000 feet above the sea-level, and its numerous flanks and spurs, forms a conspicuous feature in the topography of the northern part of the State. The enormous bodies of iron-ore offered at this point and their accessible position have combined to make it the first point of attack. The ore deposits of Gurumaishini occur in three parallel and separate leads (see fig. 11), which are 7,000, 5,500, and 3,000 feet respectively in length, and vary in width from 300 up to 700 or more feet. Further, there are three large, isolated, irregularly-shaped masses, the 3,000-foot peak itself being one of these. The vertical difference in level between the lowest and highest crops of ore is practically 2 000 feet.

Prospecting work on this area is not yet completed, but 15 million tons of ore have been proved to date, the average composition being :—

	Per cent.
Iron	60·0
Phosphorus	0·082
Insoluble residue	5·83
Manganese	0·42

The following analyses of samples taken in the course of the several examinations to which the deposits have been subjected are also of interest :—

——	Iron.	Phosphorus.	Sulphur	Silica.
	Per cent.	Per cent.	Per cent.	Per cent.
Average of eleven samples both solid and 'float' ore.	61·85	0·135	0·036	4·08
Average of 20 samples of 'float' ore .	61·46	0·048	0·036	3·34
Average of ten samples of solid ore .	64·33	0·075	0·021	1·64

A number of these samples was put through a complete analysis, thereby proving the absence of titanium, chromium, zinc, nickel, and cobalt (except in one case where 0·090 per cent. was found); copper, lead, and baryta; and the presence of arsenic in traces only (in one case up to 0·008) per cent.

The Gurumaishini ore will be mined by open cuts, the breasts advancing along the ridges in terraces or benches, with gravity inclines to lower the product to the bottom of the hill, where it will meet the broad gauge railway. A large proportion of the first few years' despatches will be 'float-ore,' gathered up at a very minimum of expense. The day when ore below drainage will have to be drawn upon is very far distant.

(2) Okampad.

The Okampad ore deposit is situated just west of the Khorkai river, where the latter breaks through the Sulaipat-Badampahar range. Okampad is a conspicuous peak, only slightly lower than the Sulaipat peak (2,535 feet elevation) which lies one mile to the south-west of the former. Gurumaishini lies 12 miles to the north-north-east. A representative sample of the ore gave on partial analysis:—Fe, 63·11; P, 0·029; S, *nil*; Ti, *nil*, per cent.

A 13 to 15-mile extension of the Gurumaishini Railway will tap the Okampad deposit when the time comes for its development.

The ore-body occurs as a single great lens, exhibiting at one point a scarp about 300 feet high, and covering a superficial area of some 300,000 or more square feet in plan. There are, besides, two smaller outliers, and about 165 acres of 'rich float'-ore. The immediate associates of the ore are banded quartz-iron-ore rock and a dense blackish quartzite, the latter especially abundant; all these are completely enclosed in what has been referred to in the field notes as trap. The low-lying country to the north-west is occupied by granite.

Four samples of Okampad ore, taken at two different times and by two different observers, gave the following average analysis:—Fe, 67·65; SiO_2, 1·58; P, 0·043; S, 0·012 per cent.

(3) Badampahar.

The last of three major deposits occupies the Badampahar peak (2,706 feet elevation), in the Sulaipat-Badampahar range, 8½ miles south-west from Okampad. Here again, as at Okampad, a single great lens of ore, roughly figured to be 3,000 feet long by 500 feet broad, with many smaller outliers, occupies the crest of the range, masses of rich float extending for many hundreds of feet downwards. Six hundred vertical feet were measured from the lowest observed massive outcrop to the highest. The immediate associates of the ore were seen to be banded quartzites and quartz-iron-ore rocks, with abundant rather basic holocrystalline rocks, this time recorded in

the field notes as a variety of charnockite. The lower ground to the north-west was again seen to be completely occupied by granite.

Iron-ores of the Drug district, Central Provinces.

The occurrence of valuable iron-ores in the Raipur district was not appreciated before Mr. P. N. Bose briefly referred to the chief deposits in a paper published in the *Records, Geological Survey of India*, Vol. XX, page 167, 1887. The district having been explored again on behalf of Messrs. Tata, Sons & Co. by Mr. C. M. Weld, a large area in the Dondi-Lohara Zamindari [1] in the western part of the district was taken up under prospecting license for detailed examination. The iron-ores, on account of their resistance to weathering agents, stand up as conspicuous hillocks in the general peneplain. The most striking of these is the ridge which includes the Dhalli and Rajhara hills, extending for some 20 miles in a zigzag, almost continuous line, and rising to heights of sometimes 400 feet above the general level of the flat country around. The iron-ores are associated with phyllites and are often of the usual type of banded quartz-iron-ore schists characteristic of the Dharwar system. But in places thick masses, apparently lenticular in shape, are formed of comparatively pure hematite, and one of these in the Rajhara hills has been subjected to very careful examination by diamond drilling. The Rajhara mass was carefully sampled across the surface at each point selected for a drill hole and the cores obtained were also analysed in lengths representing successive depths of 10 feet each from the surface, giving altogether 64 samples which were assayed for iron, phosphorus, sulphur, silica, and manganese. The average results obtained for the surface samples were as follows:—Fe, 66·35; P, 0·058; S, 0·108; SiO_2, 1·44; Mn, 0·151 per cent.; while for the cores the averages were:—Fe, 68·56; P, 0·064; S, 0·071; SiO_2, 0·71; Mn, 0·175 per cent.

In this mass the prospecting operations thus proved the existence of 2½ million tons of ore carrying about 67·5 per cent. of iron and a phosphorus content only slightly below the Bessemer limit. The quantity estimated is that which may be regarded as ore in sight while almost certainly much larger quantities may be obtained by continuation of the ore-bodies beyond their proved depth. There are other large bodies of ore in this area which

[1] This portion of the Raipur district has been included in the new district of Drug formed in 1906.

have not been examined in the same detail. These masses of hematite include small quantities of magnetite, but separate determinations of the iron in the ferric state have not been made in order to determine the relative proportions of the two minerals.

Iron-ores of the Jubbulpore district.

In addition to the results of prospecting operations conducted for the Tata Iron and Steel Company in Mayurbhanj and the Central Provinces, valuable information has been collected by Mr. E. P. Martin and Professor H. Louis in the Jubbulpore district. Prospecting operations conducted in this area on behalf of the Right Hon'ble Sir E. Cassel showed that while iron-ore is widely distributed and the formations in which it occurs are prominent in the district, there are no rich ore-bodies of large size that could be relied on for the output necessary to maintain an important industry, and most of the ore, being in the form of soft micaceous hematite, would be physically unfit in its natural condition for use in a blast furnace. Generally, also, the ores in this district contain a proportion of phosphorus too high for acid Bessemer steel.

The following analyses, extracted from Messrs. Martin and Louis' report (*Agricultural Ledger*, Calcutta, 1904, No. 3), give an idea of the nature of the ore in the principal occurrences in the Jubbulpore district :—

TABLE 48.—*Assays of Jubbulpore Iron-ores.*

——	Iron.	SiO_2.	S.	P.	Moisture.
I. *Agaria hill.* Lateritic cap covering most of the hill. 3 samples.	57·58	7·28	0·02	0·125	0·45
	56·85	8·17	0·02	0·125	0·67
	45·67	13·90	0·03	0·187	0·69
Soft micaceous hematitic schists. Ore-layers only. 2 samples.	60·70	7·45	0·019	0·075	0·25
	58·40	8·40	0·022	0·081	0·33
II. *Agaria ridge.* Bed of hematite 4 to 5 feet thick, dipping 50°.	50·07	11·37	0·036	0·074	0·44
III. *Jauli.* Soft, banded hematite-quartz schists. Picked samples.	64·67	3·70	0·027	0·023	0·30
	54·64	16·05	0·033	0·200	0·48
	65·50	3·37	0·032	0·110	0·33
	55·22	17·32	0·030	0·053	0·21

Near Sihora siliceous brown hematites were found poorer in iron but physically more suitable for the blast furnace, and in this area there occur patches of manganiferous iron-ore.[1] The following analyses were obtained from samples obtained at Mansakra (Silondi) near Sihora :—

——	Fe.	Mn.	SiO_2.	S.	P.	Moisture.
Wider band	52·15	0·36	14·70	0·022	0·385	0·10
Narrower band	44·95	6·28	14·55	0·027	0·352	0·27
Manganiferous iron-ore .	24·45	21·47	19·60	0·022	0·163	0·80

Mysore.

Iron-ores are known to occur in large quantities in the Mysore State, and have been investigated by the Mysore Geological Department. We are indebted to Dr. W. F. Smeeth for the following notes :—

The ores appear to belong to various phases of the Archæan complex and to differ considerably in their modes of origin. The hematite ores of the Bababudan Hills are by far the most abundant and are of good quality, but vary considerably in the amount of phosphorus that they contain. The following classification seems to be in accordance with the numerous observations so far recorded :—

(1) Banded ferruginous-quartz rock which occurs as a common integral component of the Dharwar schists. The banded ferruginous-quartzites are very widely distributed and vary greatly in the respective proportions of magnetite and hematite present. A number of samples from the scarps of the Bababudan Hills gave averages of 38 per cent. and 42 per cent. of iron, but many of the outcrops contain less. When the proportion of magnetite is high and the material capable of magnetic concentration, the rocks may be regarded as iron-ores, and of such there is undoubtedly a very large supply.

(2) Desilicified portions of (1) with, in some cases, addition of iron from solution or by metasomatic replacement of quartz and silicates. These form rich hematite and limonite ores. The banded ferruginous-quartzites are usually steeply inclined, but sometimes lie nearly horizontal. This latter is the case over the eastern portion of the Bababudan Hills, where these rocks form an undulating capping of from 200 to 500 feet in thickness on top of the greenstones and hornblende schists at an elevation of about 5,000 feet. In this area the banded quartzites outcrop where there are sharp local folds or crumples or where there has been

[1] *Cf.* F. R. Mallet, *Rec. Geol. Surv. Ind.*, XVI, pp. 101–103, (1883) :
L. L. Fermor, *Trans. Min. Geol. Inst. Ind.*, I, p. 99, (1906), and *Mem. Geol. Surv. Ind.*, XXXVII, pp. 814, 815, 821–823, (1909).

much denudation. On the more gentle dips and undulations solution of the silica has been active and has caused the removal of the quartz to a depth of many feet. The result is the production of a more or less banded and porous layer of hematite ore to a variable depth, in places 10 feet and probably deeper. A sample taken to a depth of 9 feet gave the following analysis :—

Moisture at 100° C. = 0·36 per cent.
On ore dried at 100° C.

H_2O	6·00	Fe	58·37
Fe_2O_3	82·79	P	0·057
FeO	0·54	S	0·047
MnO	0·08		
Al_2O_3	9·82		
MgO	0·26		
CaO	0·13		
SiO_2	0·77		
P_2O_5	0·13		
SO_3	0·118		
	100·728		

(3) Zones or layers of massive ore,—probably the result of the metasomatic replacement of silicates (igneous and metamorphic schists) by oxides of iron. These are either limonites or hematites and are sometimes associated with (1) and sometimes not. In some places they are associated with manganese-ores. Such ore-bodies have been found amongst the steeply inclined schists of the Shimoga district and also in the Chitaldrug schist belt, in both cases near or adjacent to manganese-ores. As regards quantity, there can be no doubt that a very large supply of fairly good ore can be obtained from various points on the eastern section of the Bababudan Hills, but no satisfactory estimate would be possible without extensive prospecting.

Of ores containing about 64 per cent. Fe a few million tons could probably be obtained, but it is questionable whether it would be worth while to pick such a high grade in iron. Of ores running about 60 per cent. Fe probably some 25 to 50 million tons could be obtained in several large deposits, and of lower grade ores, down to 55 per cent. iron, the quantity might safely be put at 100 millions and probably at several times this amount.

(4) Magnetite and hematite lenses which appear to be of magmatic origin associated with ultra-basic rocks intrusive into the Dharwar schists. They are usually highly titaniferous.

A number of long lenticular outcrops of these iron-ores have been found in the Channagiri Taluk. The ores from a large number of outcrops have a strong family resemblance, and of the more massive varieties several hundred thousand tons are easily available. Partial analysis of

a number of samples showed that the ores were all very similar, and a more complete analysis of one gave the following :—

	Per cent.
H_2O (total)	1·23
SiO_2	0·88
Fe	56·82
S	0·049
P	*Nil.*
MnO	0·48
Cr_2O_3	3·09
Al_2O_3	1·79
CaO	0·72
MgO	1·58
TiO_2	11 60

The large amount of titanium spoils these ores for smelting purposes. The absence of phosphorus and the presence of chromium are features of all the samples. Some ores of this series also occur in the Nuggihalli schist belt of the Channarayapatna taluk, where they are closely associated with chrome ores in a series of amphibolites and peridotites.

(5) Quartz-magnetite ores, which appear to be of magmatic origin and genetically related to the charnockite series and therefore subsequent to the Dharwar schists and to the Archæan gneiss. These ores occur in the Malvalli taluk north of the Cauvery river, where the charnockite masses of Kollegal penetrate the older gneiss and schists in tongues and dyke-like intrusions. They are found also in parts of the Mysore district.

Numerous gradations have been observed between the normal basic charnockite and these ores, in which we get increases in the proportion of the magnetite and quartz with diminution of the felspar and ferromagnesian constituents, and finally a rock composed essentially of quartz and magnetite with a little accessory hypersthene, amphibole, or garnet. The rock occurs in long thin lenses or dykes in the more normal charnockites or in the older gneissic complex, and the constituent minerals are usually granular without any marked tendency to a banded arrangement.

Goa and Ratnagiri.

In 1912 a visit was paid to certain iron-ore deposits being opened up by the Compagnie des Mines de Fer de Goa in the Portuguese territory of Goa, and by Messrs. Jambon & Co. in the adjoining British district of Ratnagiri.[1] The iron-ore of these localities is of Dharwar age and crops out in the midst of laterite, and, as seen at the outcrop, is a hard ore composed either of limonite or of hematite containing minute crystals of magnetite. At Bicholim in Goa the principal ore band has been traced for a distance of 7 kilometres and is said to vary in width from 30 to 100 metres. Such work as had been carried

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLIII, p. 18, (1913).

out in 1912 indicated that this hard ore is probably the surface hydrated form of friable schistose micaceous hematite, which is found unaltered at a relatively small distance, approximately 50 feet, below the surface. On account, however, of the extent of the outcrops, the hard superficial ore is probably available in large quantities, and, as analyses indicate it to be of high grade, with a very low percentage of silica, and phosphorus below the Bessemer limit, it seems probable that Goa possesses valuable iron-ore reserves. Some of the deposits are only 4 miles from navigable water and it is therefore not impossible that the Company may succeed in their project of mining iron-ore for export to Europe. The mining of the friable schistose hematite, when the surface ores are exhausted, will be another problem and depend for its success on the discovery of a cheap and easy method of bagging or briquetting. The iron-ore deposits near Redi in the Ratnagiri district are very similar to those of Bicholim and may also when opened up prove to be of considerable size.

The native smelting industry.

The indigenous methods of smelting iron have been frequently described for various districts in India, and no new features in the methods have recently been noticed. The industry still persists in a few districts of Bengal and Bihar and Orissa, for instance, in the Santal Parganas, Monghyr, Sambalpur, and Orissa; in the Kumaon hills; in Mysore; the districts of Malabar, Salem, and Trichinopoly of Madras; in Hyderabad, and in several States in Central India and Rajputana. The industry shows signs of greater activity in the Central Provinces than elsewhere.

The native smelting industry in the Central Provinces.

In the Central Provinces the native smelting industry has been carried on during the five years in nine districts. The average number of furnaces at work during the period was 428, the most important districts being Raipur, Bilaspur, and Mandla, as will be seen from table 49. Returns showing the quantity of iron produced in these furnaces are no longer available, but the average annual production was probably much the same as it was during the preceding five years, *viz.*, 557 tons for the entire province. At one locality, Ghogra, in Jubbulpore district, manganiferous iron-ore is smelted with production of a steely iron known as *kheri*.[1]

[1] *Mem. G. S. I.*, XXXVII, p. 595.

TABLE 49.—*Number of Iron-smelting furnaces at work in the Central Provinces during the period 1909-13.*

DISTRICT.	1909.	1910.	1911.	1912.	1913.
Saugor	13	18	19	19	19
Jubbulpore	26	24	27	30	29
Mandla	65	63	63	52	49
Narsinghpur	4	2	..	..	..
Chanda	9	5	13	9	20
Balaghat	4	4	4	4	
Raipur	230	238	No return.	228	181
Drug	56	49	39	36	40
Bilaspur	103	91	84	73	99
TOTAL	**510**	**494**	**249**	**451**	**437**

The native smelting industry in Garhwal.

Iron-ore occurs at numerous places along the outer Himalaya, the rocks being similar lithologically to some of the Dharwars of Peninsular India. Owing to the abundance of timber and, until recently, the absence of railway transport by which cheap foreign iron and steel have been distributed, the *lohar*, or *agaria* as the native smelter is sometimes called, flourished to a later date than in the more accessible parts of the Peninsula, and the industry of iron smelting still persists in a languishing condition. The necessity of curtailing the indiscriminate cutting of forests, the readiness with which a large variety of foreign implements can be obtained in the bazars, and the higher wages obtainable on account of the general progress of the country have all combined to encourage the *lohar* to leave his ancestral calling for other industries, although a few workers still occupy their leisure during slack seasons in smelting, and the native-made product is preferred to foreign iron when it can be obtained readily.

In the higher parts of the Garhwal district the fuel used is the charcoal of the *buran* (rhododendron) and *ayas* (oak), while the *chir* tree (*Pinus longifolia*) is used in the lower hills. The simple 'bloomeries' used are not unlike those generally used on the plains. The purified wrought iron obtained from about one maund (82 lbs.) of ore weighs only about 10 lbs., which, when made up into rough implements like hoes, hammers, and crowbars, sells at about Rs. 3-12 (5*s.*), and to produce this amount labour and charcoal (1½ maunds) to the cost of Rs. 2-2 (2*s.* 10*d.*) are required.

The *lohars* of Garhwal are regarded as belonging to a higher of the low caste *doms.* They regard as the founder of their caste one Kaliya *lohar,* who is supposed to have supplied the Pandvas with their fighting weapons, and he is now propitiated before each smelting operation with an offer of five pieces of charcoal.

Imports.

Except for the pig-iron and steel produced at Barakar and Sakchi (which amounted to 473,745 tons of pig-iron and 156,993 tons of steel during the period under review, as compared with a total of 209,595 tons of pig-iron produced at Barakar during the previous five years), practically all the iron and steel used in India is imported; the steel furnaces in the Government Ordnance Factories and in the East Indian Railway works at Jamalpur are supplied mostly with scrap steel and imported pig, while the iron produced by indigenous methods amounts to only about 1,000 tons a year. The imports of pig-iron averaged 13,130 tons a year during the past five years 1909 to 1913, as compared with an annual average of 30,974 tons during the previous five years. The requirements of the country in iron and steel are indicated by the import returns summarised in table 50. From this it will be seen that the total value of the unfinished and finished iron and steel products imported into India fluctuated considerably, having ranged from a little over 15½ million pounds in 1910 to nearly 27 million in 1913, the average annual value being £19,330,918 as against £16,910,432 for the preceding quinquennium. A marked feature is the great increase in the imports of iron and steel beams, etc., in 1913.

TABLE 50.—*Imports into India of Iron and Steel Materials during the years 1909 to 1913.*

—	1909.	1910.	1911.	1912.	1913.	*Average.*
	£	£	£	£	£	£
Cutlery and hardware.	2,015,228	2,115,635	2,351,355	2,566,315	3,006,104	*2,410,927*
Machinery and millwork.	4,097,346	3,408,064	3,245,496	3,468,397	5,174,050	*3,878,672*
Railway plant and rolling stock.	6,254,536	3,654,743	4,627,259	5,432,748	8,622,887	*5,718,435*
Iron bars, pig-iron, etc.	5,816,405	378,210	349,846	371,220	419,702	*7,322,884*
Iron and steel beams, sheets, pillars, rivets, etc.		5,183,019	5,269,401	5,985,542	8,028,182	
Steel bars, angle and channel, ingots, blooms, billets, etc.		940,558	1,154,503	1,028,338	1,694,495	
TOTAL .	**18,183,515**	**15,675,229**	**16,997,860**	**18,852,560**	**26,945,429**	*19,330,918*

Jadeite.

Exports.

The mineral jadeite, like the true jade (nephrite) with which it is often confused, is especially prized by the Chinese, and the quarrying of the mineral forms quite an important industry in Upper Burma. Some of the mineral raised passes by the overland route into South-West China (Yunnan), but most of it finds its way down to Rangoon, whence it is exported to the Straits Settlements and China. Table 51 shows the extent of this export trade. From this it will be seen that the average annual export during the period under review was 4,700 cwts., as compared with an average figure of 3,470 cwts. for the period of the previous review.

Prices.

The prices paid for rough stone vary too much to permit of an average figure being given, but the export values declared give an idea of the value of the stone; from table 51 it is seen that the value so determined has averaged £15·38 per cwt. during the period under review, being a decrease of 46 shillings per cwt. on the average price during the preceding period of five years. A very striking feature of the returns is the rapid decrease both of exports and of value between 1910 and 1913; this falling off may be due in some part to troubles in China which is the chief market for jadeite, but the decrease in value points also to the production of inferior material.

TABLE 51.—*Exports of Jadestone from Burma for the years 1908-09 to 1913-14.* (*a*)

YEAR.	Weight.	Value.	Value per cwt.
	Cwts.	£	£
1908-09	4,088	*84,450*	20·66
1909-10	5,512	*91,410*	16·58
1910-11	6,165	*99,601*	16·16
1911-12	2,028	*29,815*	14·70
1912-13	2,102	*19,853*	9·45
1913-14	3,602	*36,194*	10·05
Average .	*4,700*	*72,265*	15·38

(*a*) Overland trade and exports *viâ* Rangoon combined.

Value of jade.

Amongst prehistoric relics found in various parts of the world, both nephrite and jadeite implements and ornaments are widely distributed, and an admiration for the beauty of the stone, descended from a belief in its magical properties, maintains the value of the mineral in the eyes of the Chinese, who are the chief buyers, and to whom the different varieties of both minerals, and possibly some others, are known under the generic name *yu-esh.* The softer, serpentinous mineral, bowenite, passes on the North-West Frontier under the name of *sang-i-yeshm,* and though its characters are unmistakably distinct from those of nephrite and jadeite, it is evidently regarded as a poor variety of jade.

Composition.

Two distinct minerals are included in the term jadestone or jade, namely, the true *jade* or *nephrite,* which is a silicate of calcium and magnesium, $CaO.3MgO.4SiO_2$, and a member of the amphibole group: and *jadeite,* which is a pyroxene of the composition $Na_2O.Al_2O_3.4SiO_2$ (silicate of sodium and aluminium). They are very similar in colour and other physical properties, but jadeite is slightly the harder and considerably heavier of the two, and is more fusible. They are prized equally by the Chinese. No jade (nephrite) of the kind that would be regarded as a marketable mineral is known in India. But a mineral, having the essential composition and approaching coarse jade in physical characters, is known in South Mirzapur.[1] True jade, however, has been largely worked in the Karakash valley in South Turkestan for many centuries.[2] The only jadestone of commercial value found in the Indian Empire is the jadeite found in the basin of the Uru river, a tributary of the Chindwin, in the Mogaung sub-division of the Myitkyina district, Upper Burma.

Mode of occurrence.

Jadeite is now worked at three localities—Mamon, Hweka, and Tawmaw (25° 44′; 96° 14′). At *Mamon* the jadeite is found in the form of boulders in the alluvial deposits of the Uru river, and also in the bed of the river itself. At *Hweka* the mineral is found in the form of boulders in a conglomerate of Tertiary age. But the most interesting of the three occurrences is at *Tawmaw.* Dr. A. W. G. Bleeck[3] describes the jadeite of Tawmaw as occurring in a meta-

[1] F. R. Mallet, *Rec. Geol. Surv. Ind.,* V, p. 22, (1872).
[2] *Cf.* papers quoted by Mallet in Manual, Geol. of Ind., Part IV, p. 85, (1887).
[3] 'Jadeite in the Kachin Hills,' *Rec. Geol. Surv. Ind.,* XXXVI, pp. 254—295, (1908).

morphosed igneous dyke intruded into serpentine. He concludes that the jadeite is the result of the metamorphism of an albite-nepheline rock originally forming the dyke. The change would be represented chemically as follows:—

$NaAlSiO_4$ (nepheline)+$NaAlSi_3O_8$ (albite)=$2NaAlSi_2O_6$ (2 jadeite).

Under certain conditions of crystallisation nepheline-albite rocks might be formed, while under conditions of high pressure, during consolidation or after, jadeite, which has a much lower molecular volume, would be produced, the residual molecule forming albite or nepheline, according to which molecule was in excess in the original magma. (The albite molecule was the one in excess; for this mineral occurs in a mixed zone of albite and jadeite on each edge of the dyke.) The serpentines form a long ridge flanked on either side by saussuritic gabbros, saussuritic glaucophane-schists, and chlorite-schists. These rocks are traversed by granite and veins of quartz; all the rocks are regarded as genetically related and as the results of the differentiation of the same magma, which gave rise successively to the peridotites, gabbros, nepheline-albite (jadeite) rock, and the siliceous end-products—granite and quartz.

Jadeite has also been found in the Mawlu township of the Katha district.

History of the jadeite trade.

The following notes on the history of the jadeite industry are taken from a copy of the chapter on the jade-mining industry prepared for the Myitkyina District Gazetteer by Mr. W. A. Hertz, and kindly supplied by the Government of Burma. This in its turn is largely based on a report by Mr. Warry of the Chinese Consular Service written in 1888, and is so interesting that a perusal of the full chapter in the Gazetteer [1] will well repay the reader for the time spent. In the following paragraphs the term *jade* is used in its generic sense, referring in the case of Burma to jadeite.

According to Mr. Warry, jadestone or nephrite has been known in China from a period of high antiquity. It was found in Khotan and other parts of Central Asia, the most valued variety being the costly milk-white kind held in high esteem as symbolical of purity in private and official life. The discovery that green jade (jadeite) of fine quality occurs in Northern Burma was made accidentally by a small Yunnanese trader in the thirteenth century, who, to

[1] Vol. A, (1912), pp. 104—119.

balance the load on his mule, picked up a piece of stone, which was later found to be jade of great value. For some centuries small pieces of stone found their way across the frontier, but it was not until 1784, after protracted hostilities between Burma and China, that a regular trade was opened between the two countries, and then the Chinese soon discovered the position of the jade-producing district. At the beginning of the nineteenth century the Burmese kings seem to have become aware of the importance of the jade trade and the revenue it might yield, and in 1806 a Burmese Collectorate was established at the site of what is now the town of Mogaung, which became the head of the jade trade in Burma. The Kachins, in whose country the jade deposits are situated, and who were regarded as the absolute owners of all the jade produced, brought the mineral to Mogaung, where it was sold to the Chinese. When it was ready to leave Mogaung an *ad valorem* duty of $33\frac{1}{3}$ per cent. was levied and a permit issued. Payments were made in bar silver—at first fairly pure, but later on debased with lead (rupees did not come into general use until 1874).

The period of greatest prosperity of the jade trade was 1831-1840, during which time at least 800 Chinese and 600 Shans were annually engaged in business and labour at the mines. All the stone went by one of several routes to Yunnan-fu, then the great emporium of the jade trade, where Cantonese merchants bought the rough stone and carried it to Canton to be cut and polished. In 1841 war broke out between Great Britain and China and the hostilities at Canton soon affected the jade trade, so that the Cantonese merchants ceased to go to Yunnan-fu, to buy stone. Stocks accumulated and Yunnan traders ceased visiting the mines. The trade passed through various vicissitudes, but it was not until 1861 that it really improved again. From that date, when the first Cantonese merchant arrived in Mandalay and made a fortune by buying up all the old stocks of jade, till now, the bulk of the stone has been carried by sea to Canton. During the ensuing years, the jade dues were sometimes collected in the orthodox way—by the Collector at Mogaung—whilst in other years the tax was farmed out; but the King of Burma, dissatisfied with the revenue thus obtained from jade, tried in some years to purchase all the material himself direct from the Kachins at the mines. In such years the Kachins, preferring the former revenue methods, curtailed the out-

put and produced pieces of inferior quality only. The revenue accruing to the King from the jade dues varied from Rs. 10,000 per annum to Rs. 50,000, being least when the King tried to purchase the jade himself. With the British occupation of Upper Burma the tax was farmed out to Leonpin, who made himself so unpopular by his methods of collecting the tax that he was murdered at Mogaung. The first British visit to the mines was made in 1888 by Major Adamson with a column of British troops. The tax of 33⅓ per cent. on output is still farmed out by Government. It is collected at Mogaung in the case of stone transported on mules *viâ* Kamaing, and at Kindat in the case of stone transported on bamboo rafts down the Uyu and Chindwin.

The amounts realised on account of this farm during the period under review are shown below :—

1908-09	70,900	rupees per annum.
1909-10	84,000	"
1910-11	84,000 [1]	"
1911-12	44,133	"
1912-13	12,495	"
1913-14	34,285	"

The farm includes also the right to collect the royalty on *amber* at 5 per cent. *ad valorem* in the Myitkyina and Upper Chindwin districts. This system is particularly pernicious and is one which readily lends itself to abuses, it being to the interest of the lessee of the royalty as well as to that of the producer to keep the returns of production as low as possible ; and it is probable that much material is smuggled away, thus escaping the payment of royalty. Clearly no reliance can be placed on the official returns embodying the figures for the production at the mines, since these show the *total output* for the years 1908-09 to 1913-14, *i.e.*, from April 1st, 1908, to March 31st, 1913, as 13,912 cwts. valued at £76,445, while during the same period the exports were 23,497 cwts. valued at £361,323, or nearly 10,000 cwts. more than the actual output and having a value nearly five times as high.

In addition to the export duties collected by Government, various dues are levied at the mines by the *Sawbwa* of Kansi, who is the headman of the jade tract.

[1] This is a little lower than the actual figure, which is not available.

The actual work of quarrying is carried out by the Kachins during the dry months of the year. At Tawmaw, where the rock occurring *in situ* is quarried, considerable difficulty is experienced in extracting the tough rock, and it is found necessary to resort to splitting by fire, it is said to the detriment of the stone. The use of explosives and also of pumps is, however, being adopted, but the industry appears to be in a moribund condition and unless steps are taken to revive it and to place it on a more satisfactory basis, it does not seem likely to survive much longer.

Lead, Silver, and Zinc.

Galena, the sulphide of lead, occurs in a large number of places in India and Burma, and is often argentiferous. The oxide and carbonate of lead are also commonly found in parts of Chota Nagpur and the Santal Parganas of Bihar and Orissa. Formerly the mineral was worked on a small scale; but the industry gave way before the cheaply imported metal. But with the increasing demand for lead attention is being directed to the Indian and Burmese occurrences. As far as is at present known ores of zinc are not at all common in the Indian Empire; they have been found associated with the antimony-ores of Shigri in Lahaul, with the silver-lead ores of Bawdwin in the Northern Shan States, and with the copper-ores of Sikkim. No successful attempts to extract the metal have yet been made by Europeans, but up till about a century ago, zinc was extracted from carbonate of zinc (smithsonite) at Jawar or Zawar in Udaipur State, Rajputana.

Bihar and Orissa : Manbhum.

In 1904 and 1905 Messrs. Mackinnon, Mackenzie & Co. of Calcutta opened up a deposit of galena and quartz in mica-schist at Beldi in the Birbhum Estate in the Manbhum district, Bihar and Orissa. The deposit turned out to be a surface pocket, and gave out at a small depth. All the ore visible was extracted and railed to Howrah, and smelted in a small furnace that had been erected for the purpose at Shalimar near Calcutta. The total amount of ore smelted was :—

(*a*) 120 tons of galena containing about 50 per cent. of silver-lead.

(*b*) 147 tons of rubble and quartz containing about 25 per cent. of silver-lead.

The total yield from this was 92 tons 16 cwts. 1 qr. 7 lbs. of silver-lead, which was sold in London, the yield from it being:

86·04 grains of gold.
4,716·15 ozs. of silver.
91 tons 9 cwts. 1 qr. 13 lbs. of lead.

The proceeds of the sale just met the total expenses of the mining, smelting, etc. Eight other localities—Janijhore, Kushboni, Lataparah, Lewshai, Parada, Ghagra, Nannah, and Dekia—in the same district were also thoroughly prospected. All the occurrences were in mica-schist, and proved to be barren in depth, and no true continuous lode was found.[1]

Sikkim.

In Sikkim lead is found in the form of galena at Pachi Colah, and enters into the composition of certain characteristic mixed sulphide lodes, as at Bhotang, Pachi Colah, and some other places; whilst zinc is found associated with some of the copper-ores in the form of calamine, and is nearly always associated with pyrrhotite and pyrite lodes in the form of blende.[2]

Burma: Bawdwin.

At the time when the Review for the period 1904-08 was written there were indications that the argentiferous lead slags of Bawdwin in Upper Burma might soon form the basis of a new Indian industry; during the period now under review these expectations have been realised and nearly 46,000 tons of lead and 400,000 ounces of silver were extracted by the Burma Mines, Ltd.

The existence of the ancient silver-lead mines of Bawdwin-gyi in Tawngpeng, one of the lesser Northern Shan States, has long been vaguely known. They were worked by Chinese from Yunnan for a very long period until about fifty years ago, when they were deserted. Traces of the Chinese activity are everywhere apparent, notably in the numerous galleries driven into the hill-sides for the extraction of the ore, and in the enormous heaps of zinc-lead slag that were thrown away after smelting out a portion of the lead with the bulk of the silver. A concession over this area was taken up by the Great Eastern Mining Company, Ltd., in about 1902; the old workings were partially re-opened, and a light railway commenced, to connect the mines with Manhpwe station a few miles above

[1] We are indebted to Sir D. M. Hamilton for this information.
[2] From the report by C. Wilkinson—see p. 260.

Hsipaw on the Shan States branch of the Burma Railways, a distance of some 50 miles through mountainous country. The property was eventually sold to the Burma Mines, Railway and Smelting Company, Ltd., now the Burma Mines, Ltd., and the railway was completed in December 1909.

Up till the end of 1908, practically the whole of the capital and energy of this Company was devoted to the completion of the railway mentioned above, so that no smelting was carried out. During the year 1909, however, 11,850 tons of lead slag lying on the surface at the mines, and 485 tons of ore obtained from open-cut workings, were transported to the Mandalay smelters and treated for a return of 5,030 tons of lead and 27,500 oz. of silver. The whole of this metal was shipped to London for refinement and sale, where it realised the sum of £68,100. During the latter part of 1911 and early part of 1912, the smelting plant was removed from Mandalay to Namtu, and during the year 1913, 5,857·57 tons of base bullion lead were produced, part of which was refined in the Company's plant at Namtu.[1] The statistics of production during the quenquennium are shown in table 51A.

TABLE 51A.—*Production of Lead and Silver from Bawdwin Ore and Slag during the years 1909 to 1913.*

—	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons	£	Tons.	£	Tons.	£	Tons.	£
Lead-ore . .	485	..	975	..	3,218	..	2,950	..	3,939	..	2,313	..
Slag . . .	11,850	..	29,533	..	31,954	..	22,563	..	16,360	..	22,452	..
TOTAL .	**12,335**	..	**30,508**	..	**35,172**	..	**25,513**	..	**20,299**	..	**24,765**	..
Lead extracted .	5,030	*65,350*	12,896(*a*)	*161,542*	13,185	*181,271*	8,531	*152,830*	5,858	*71,511*	9,100	*126,501*
Silver extracted (ounces).	27,500	*2,750*	49,080	*4,968*	103,850	*11,575*	93,476	*11,829*	125,209	*15,338*	79,943	*9,292*
TOTAL .	..	*68,100*	..	*166,510*	..	*192,846*	..	*164,659*	..	*86,849*	..	*135,793*

(*a*) Estimated in part.

[1] Information kindly supplied by the Resident Manager of the Burma Mines, Ltd.

One 200-ton blast furnace is in regular operation, at present chiefly on the old Bawdwin slags, but increased capacity is being arranged for. It is not possible to estimate accurately the amount of slag still available, but it was believed, at the end of the year 1913, to exceed 50,000 tons.

Concurrently with the smelting of the slags, a considerable amount of development of the old mines was carried on and the company eventually came to the conclusion that the property constituted a valuable mining proposition. Since the close of the period with which this Review deals, re-organisation has been carried out and most of the property taken over by the Burma Corporation, Ltd., whose nominal capital in May 1914 was £1,000,000. It is proposed at first to treat only part of the ore locally, the rest being sold in Europe. The ores are mainly of three kinds:

(1) Zinc-silver-lead ore,
(2) Lead-silver-zinc ore,
(3) Copper-silver ore.

According to a report of the technical committee of the Burma Corporation, dated April 28th, 1914, four main ore-bodies are recognised at present:

(*a*) Burman lead-zinc ore-body, said to carry 33 per cent. lead, 16 per cent. zinc and 37 oz. silver;
(*b*) Shan copper ore-body, said to carry 15·4 per cent. copper and 7·8 oz. of silver;
(*c*) Chinaman lead-zinc ore-body, said to carry 24·3 per cent. lead, 14·2 per cent. zinc and 17·5 oz. silver;
(*d*) Chinaman zinc-lead ore-body, said to carry 26 per cent. lead, 29·8 per cent. zinc and 23·6 oz. silver.

A paper dealing with the geology and mineralogy of these deposits in Bawdwin by Messrs. T. D. LaTouche and J. Coggin Brown was published in 1909.[1] The ores occur in a zone of intense disturbance, caused by one or more great overthrust faults traversing the rocks, which are felspathic grits and rhyolitic tuffs, probably of Cambrian age. They consist for the most part of argentiferous galena and zinc-blende, with a small quantity of copper pyrites in minute granules. The other minerals found are anglesite, cerussite, barytes, pyrite, malachite, azurite, and smithsonite (zinc carbonate). The deposition of the ores has been accomplished by the

[1] *Rec. Geol. Surv. Ind.*, XXXVII, p. 235, (1909).

metasomatic replacement of the felspar and other rock-forming minerals present.

Argentiferous galena is worked by Shans in two States in the Myelat division of the Southern Shan States. These are Mawsön (Bawzaing) and the Kyauktat Sub-State of Yaunghwe. The combined output in 1908 was 63½ tons valued at £79. The production of lead-ore from the Southern Shan States during the period 1909-13 averaged 81 tons valued at £191 annually.

Burma : Mount Pima.

In the foothills of Mount Pima, Yamethin district, 16 miles north-east of Pyawbwe, a lode of argentiferous galena, said to be from 3 to 30 feet thick, was discovered during the period covered by the last Review. A company was floated in 1908, with a capital of Rs. 20,00,000, to work the property; a light railway was laid down and concentrating plant acquired, but unfortunately the necessary precaution of ascertaining the amount of ore likely to be available was neglected, and soon after operations had begun it was found that the ore-body was merely a 'pocket' and the supply of ore exhausted. A output of 2,463 tons of ore valued at £517 was returned for the year 1909.

A small production of lead-ore is also reported from the Mandalay and Toungoo districts.

Central Provinces : Sleemanabad.

Some of the metalliferous lodes at Sleemanabad in the Jubbulpore district, Central Provinces, carry galena. Both this and the associated tetrahedrite, especially the latter, are sometimes very rich in silver (up to 200 oz.), but attempts to develop these lodes have not been successful.

Baluchistan.

The old lead mines of Shekran, near Khozdar in Jhalawan, Baluchistan, which are no longer worked, occur in Liassic limestones. The chief ore is cerussite.[1]

Consumption of lead.

The extent of the market in India for lead is indicated by the import figures. During the six years April 1st, 1908, to March 31st, 1914, the average annual value of the lead imported has been £140,040, as against £136,781 in the preceding quinquennium. The average annual value of the exports has been £61,629 as against £3,987. The imports consist chiefly of sheet lead for tea-chests; also of lead

[1] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 215, (1909).

pipes, sheets and tubes and of pig lead. The great increase in the average annual value of the exports, from under £4,000 to over £60,000, is due to the smelting operations of the Burma Mines, Ltd., who export to Europe the lead extracted at Bawdwin.

Production and consumption of silver.

During the period under review, silver figures for the first time in the returns of the Indian mineral production. The whole output, which amounted only to a little under 400,000 ounces, came from Bawdwin. This quantity is quite insignificant as compared with the country's requirements, for India is the largest consumer of silver in the world. The average annual imports of treasure and bullion during the period 1909-13 amounted to over 81,000,000 ounces, valued at £9,629,383; this constitutes a fall of about 33 per cent. from the average annual value during the preceding quinquennial period. At the same time the exports show a rise from an average annual value of £1,748,414 to £2,496,090, the average for the period under review.

Consumption of zinc.

There is a considerable consumption of zinc in India, imported in the form of the metal, as also in the form of brass and nickel silver. During the six years 1908-09 to 1913-14 the imports of zinc in the metallic form, unwrought and wrought, have averaged £139,782 per annum, and the exports £6,315, leaving an annual Indian consumption of £133,367. During the same period the imports of brass have averaged £88,429 annually, and the exports and re-exports £18,421, leaving a net annual consumption to the value of £70,108. Nickel-silver is an alloy of copper, nickel, and zinc of varying composition, but may be taken as consisting typically of 60 per cent. copper, and 20 per cent. each of nickel and zinc. The imports of this alloy during the same period have averaged in value £117,187 annually.

Magnesite.

Salem district.

The 'Chalk Hills' lying between the town of Salem and the Shevaroy Hills in South India were loosely so named because of the general effect of the network of white magnesite veins, which are prominent over an area of about 4½ square miles. The occurrence was well known early in the last century, when Mr. J. M. Heath, then 'Commercial' Resident (Collector) at Salem on behalf of the

East India Company, was such an energetic prospector. The area was described by W. King and R. B. Foote in 1864,[1] and the origin of the magnesite by alteration of dunite (olivine-rock) was first noticed in 1892.[2]

A more complete account of the area with map and photographs was published in 1896 by C. S. Middlemiss,[3] who drew special attention to the large quantities of mineral easily obtainable.

Attention was again directed to the place by Mr. H. G. Turner, and through his enterprise the Magnesite Syndicate, Ltd., was formed to develop the mineral. A paper by Mr. H. H. Dains [4] demonstrates the high quality of the material obtainable, the magnesite containing 96-97 per cent. of magnesium carbonate in ordinary, and 99 per cent. in picked, samples. The following analyses have been made on fair samples :—

TABLE 52.—*Analyses of Salem Magnesite.*

——	Blount.	Dains.	Pattinson (cargo sample).	Ferguson.	
				1.	2.
Silica	0·22	0·29	1·17	0·31	1·70
Iron oxide	0·30	0·65	0·14	0 40	0·65
Alumina				0·10	0·10
Manganese oxide	..	0·20	0 06	..	..
Lime	*Nil*	0·83	0·78	..	..
Magnesium oxide	47·35	46·42	46·28	97·80	97·4
Carbon dioxide	51·44	50·71	50·10		
Water	0·27	0·16	1·30	0·60	Traces.
Sulphuric acid	..	..	0·03	..	..
Phosphoric acid	..	..	0·01	..	..
TOTAL	**99·58**	**99·26**	**99·87**	**100·06**(*a*)	**99·85**
Magnesium carbonate	*98·79*	*97·13*	*96·34*	*97·80*	*97·40*

(*a*) Including 0·85 calcium carbonate.

[1] *Mem. Geol. Surv. Ind.*, IV, pp. 312—317.
[2] T. H. Holland, *Rec. Geol. Surv. Ind.*, XXV, p. 144, footnote.
[3] *Rec. Geol. Surv. Ind.*, XXIX, p. 31.
[4] 'The Indian Magnesite Industry.' *Journ. Soc. Chem. Industry*, XXVIII, p. 503, (1909).

The magnesite is calcined on the spot to produce (*a*) lightly calcined or caustic magnesia, obtained at a temperature of about 800° C., and (*b*) dead-burnt, sintered, or shrunk magnesia, obtained by calcination at about 1,700° C. The following analyses, given by Mr. Dains, represent the two products as obtained in gas-fired kilns :—

TABLE 53.—*Analyses of Calcined Salem Magnesite.*

——	Caustic magnesia.		Dead-burnt magnesia.
Loss on ignition	1·82	2·31	0·34
Silica	..	..	4·38
Insoluble residue	1·13	0·54	..
Ferric oxide and alumina	0·63	0·44	1·12
Lime	1·06	1·03	1·04
Magnesia	95·80	96·10	93·12
TOTAL .	100·44	100·42	100·00

Experiments made on a considerable scale on behalf of Mr. H. G. Turner[1] showed that when highly heated in an electric furnace the Salem magnesite yields a hard dense crystalline mass of the greatest refractory quality.

Uses of magnesite.

Magnesite has many applications, of which its use as a source of carbon dioxide and as a refractory material are amongst the most important.[1] But practically the whole of the lightly calcined magnesia of Salem is shipped to Europe for use as Sorel Cement for the manufacture of artificial stone, floorings, etc. This cement is formed by mixing caustic magnesia with a solution of magnesium chloride and will carry up to 20 parts of sand for one of magnesia.

[1] See previous review, p. 126.

TABLE 54.—*Production of Magnesite in the Chalk Hills near Salem during the years 1909 to 1913.*

YEAR.	Quantity.	*Value.* (a)
	Tons.	£
1909	737	*196*
1910	5,182	*1,382*
1911	3,490	*1,047*
1912	15,379	*4,611*
1913	14,086	*4,153*
AVERAGE	7,775	*2,278*

(*a*) Value taken as cost price at the kilns.

Production.

The production reported for the Chalk Hills near Salem is given in table 54. Very little crude magnesite is, however, sold, the bulk of the output being converted on the spot into calcined magnesia, the production of dead-burnt magnesia having now been practically abandoned owing to cost of fuel. The production of these two products during the quinquennium was as follows :—

TABLE 55.—*Production of Magnesia in the Chalk Hills during the years 1909 to 1913.*

	LIGHTLY CALCINED.		DEAD-BURNT.	
	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£
1909	934	*3,113*	20	*80*
1910	1,744	*5,813*	45	*180*
1911	1,221	*4,070*	32	*128*
1912	2,508	*8,360*	..	..
1913	4,380	*14,600*	..	..

Other occurrences.

Magnesite is known to occur at several other places in South India, always as veins traversing peridotites, for example at Seringala in Coorg, on the Cauvery above Fraserpet, in other parts of the Salem

district,[1] in the Trichinopoly district, and in the Hassan and Mysore districts of Mysore.[2] The Tata Iron and Steel Co. has started work in the Mysore district for the production of refractory materials for their furnaces at Sakchi in Singhbhum, 2,112 tons being excavated during 1913, but none removed except for experimental purposes. According to Mr. A. Ghose large quantities of magnesite, although of inferior quality, occur in association with the steatite deposits of Muddavaram and Musila Cheruvu in the Karnul district (see page 292).

Manganese.

Progress of the industry.

The two previous Reviews recorded the rapid development of the manganese-quarrying industry of India, which reached its zenith in 1907 with an output of 902,291 tons; and its assumption, at the expense of Russia, of the first place among the world's producers of manganese-ore. The year 1908 witnessed a marked check to the manganese-ore industry both of India and Russia, owing to the general commercial depression and fall in the demand for steel. This great expansion of the Indian manganese-ore industry was due partly to great activity in the steel trade of the world during the years 1905-07, and partly, though to a small extent, to the political disturbances in the Caucasus, owing to which buyers, who once satisfied their wants from the Caucasus, were compelled to have recourse to India. The ores found in the Caucasus are soft and friable, and are worked by a large number of small workers who do not trouble to clean their ores to a uniform standard. Railway freights are high, whilst the rolling stock is said to be inadequate; the consequence is that iron masters have found it dangerous to rely too much on the Caucasus for their supplies, and prefer the Indian ore, which is not only more suitable for the blast furnaces on account of its hard lump form, but is also selected with care by the manganese companies, so that the ore exported is of a moderately uniform quality. During the present quinquennial period attempts have been made to improve the conditions of the Russian

[1] W. King and R. B. Foote, *loc. cit.*, pp. 318—324.
[2] A. Primrose, *Rec. Mysore Geol. Dept.*, III, p. 239; IV, p. 178:
V. S. Sambasiva Iyer, *op. cit.*, IV, p. 61:
W. F. Smeeth, Report, Chief Inspector of Mines in Mysore, for 1906-07, p. 37: 1912-13, p. 15.

manganese industry. A certain number of large companies have been formed, washing plants erected, and better facilities for loading provided at the port of Poti. But these measures have proved insufficient adequately to ameliorate the conditions of the Caucasian industry and especially the conditions of the numerous small workers, with the consequence that the Russian industry during the period in question has suffered from severe depression aggravated by strikes amongst the miners, high freights in some years, and overproduction. Indeed, it seems unlikely that the Caucasian industry will reach the full degree of prosperity that is possible until it is recognised in Russia that India and Brazil are certain to retain a considerable proportion of the world's market owing to the superior qualities of their ores, and until the Caucasian industry is organised and production restricted to the quantity justified by the market that can be commanded by an inferior ore.

As will be seen from the figures of production shown in table 57, the Indian industry has reached a position of comparative stability, the average annual production for the period in question being 712,797 tons; but the industry has not escaped its share of adversity, as may be judged from the fluctuations in output during the period (see fig. 5, page 21). These figures show two maxima,—one in 1910 and one in 1913—with minima in 1909 and 1912. That these fluctuations are due to variations of activity in the steel trade can be seen at once from the upper portion of fig. 12, which records two arrests in the world's production of steel in the years 1908 and 1911 and two maxima of production in the years 1910 and 1913. Thus it is seen that the maxima of manganese-ore production coincide with the maxima of steel production, whilst the minima lag one year behind, indicating apparently that there is a lag in the response of the Indian manganese industry to the variations in the activity of the steelmakers. The effect of this lag is to lead to overproduction during years of lessened demand, with the resultant accumulation of stocks, which are disposed of at times of increased demand; that this is probably the correct interpretation may be judged by comparing the production of Indian manganese-ore as recorded in table 57 with the exports of Indian manganese-ore as recorded in table 60. The varying demands of the steel trade make their effect felt on the manganese industry in part through variations in the price of the manganese-ore, and it is interesting, therefore, to compare the curves of world's production of pig-iron and steel forming the upper part of fig. 12

with the curves showing the prices of manganese-ore forming the lower part of the figure. The higher prices obtaining in 1912 and 1913 did not, however, benefit the Indian manganese producer as much as might be expected, because of the excessively high freights prevailing during those two years, which were probably in part responsible for the advance in the market price of manganese-ore.

Prices.

The prices paid per unit for manganese-ore delivered at United Kingdom ports during the quinquennium (from the *Mining Journal*) are shown in table 56, and compared diagrammatically in fig. 12 with the world's production of pig-iron and steel. Comparison should also be made with the figures of production for the same period shown in table 57 on page 140.

TABLE 56.—*Variation in the Price of Manganese-ore c.i.f., at United Kingdom Ports.*

DATE.	FIRST-GRADE ORE.	SECOND-GRADE ORE.	THIRD-GRADE ORE.
	50 per cent. Mn and upwards.	48-50 per cent. Mn.	45-48 per cent. Mn.
	Price per unit.	*Price per unit.*	*Price per unit.*
January 1909*	9¼	8¼	7¼
July 1909*	9	8	7
January 1910	9½	9¼	9
July 1910	9½	9¼	8¾
January 1911	9¼—9½	9—9¼	8⅝—8¾
July 1911	9¼—9½	9	8¾
January 1912	9½—9¾	9¼—9½	8¾—9
July 1912	10½—11¼	10¼—11	10—10½
January 1913	12—12¼	11¾—12	..
July 1913	11—11¼	10½—11	..
January 1914	10—10½	9½—9¾	9¼—9½
July 1914	9¼—9½	9—9¼	8¾—9

* Up till Dec. 1909, the three grades of manganese-ore were different (see p. 153).

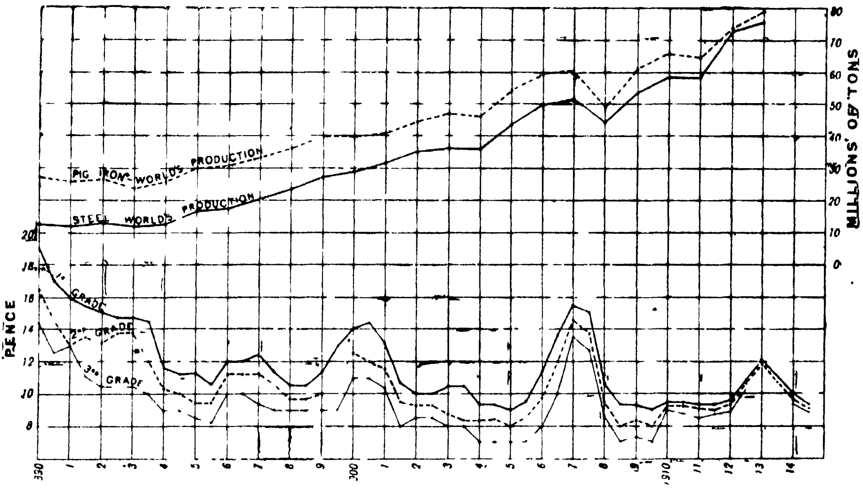


FIG. 12.—*Variation in the Prices of Manganese-ore at United Kingdom Ports since 1890, compared with the World's Production of Pig-iron and Steel.*

Companies working.

During the period now under Review the following limited companies were at work. Most of them were formed during the years 1905 to 1907; but the Vizianagram Mining Co. was floated in 1895:—

Bombay—

1. The Shivrajpur Syndicate.
2. The Bamankua Manganese Company.

Central Provinces—

1. The Central India Mining Company.
2. The Indian Manganese Company.
3. The Central Provinces Prospecting Syndicate.
4. The Netra Manganese Company.

Madras—

1. The General Sandur Mining Company.
2. The Bobbili Mining Company.

Mysore—

1. The Mysore Manganese Company, converted into:— The New Mysore Manganese Company, and absorbed by:— The Workington Iron and Steel Company in 1909.
2. The Peninsular Minerals Company of Mysore.
3. The Shimoga Manganese Company.[1]
4. The Hajee Prospecting Syndicate.[2]

[1] No production since 1909.
[2] „ „ „ 1910.

Other prominent workers during this quinquennium have been .—

The Carnegie Steel Company : Central Provinces.

The Tata Iron and Steel Company : Central Provinces.

Byramjee, Pestonjee & Company : Central Provinces.

D. Laxminarayan : Central Provinces.

Rai Bahadur Bansilal Abirchand Mining Syndicate : Central Provinces.

Madhulal Doogar : Bihar and Orissa.

Kiddle, Reeve & Company : Central India.

A. Voigt : Madras.

Production.

Table 57 shows the production from each district, state, and province during the past five years, and fig. 5 on page 21 shows the progress of the industry since its beginning. From this it will be seen that the Central Provinces is by far the most important province as a producer of manganese. The figures in this table represent, except in a few cases, quantities of ore won or raised, and not of ore railed.

Comparing this quinquennium with the previous five years it will be seen that the average annual production of manganese-ore for the whole of India has increased substantially from 509,143 tons to 712,797 tons. But when comparisons are instituted for the separate districts and states it is seen that change has not all been positive. The four chief producing districts of the Central Provinces are responsible for the greater part of the increase, the Chhindwara district taking its proper place for the first time in 1913 owing to the extension of the Bengal-Nagpur Railway into the Sausar tahsil. Bombay Presidency also shows a large percentage increase due to the opening up of deposits in the Panch Mahals. Gangpur State in Bihar and Orissa shows a six-fold increase in the average annual production, but the figures record a change from a maximum in 1909 to a minimum in 1913. The Madras Presidency shows a small increase, which is the balance of a very great increase in the production of Sandur State and a nearly as great average decrease in that of the Vizagapatam district. On the other hand Central India shows a great reduction in output, due to the working out of the easily-won portions of the Kajlidongri deposit in Jhabua State; whilst the Mysore output has nearly halved due to a similar result in the great Kumsi deposit in Shimoga district.

TABLE 57.—*Production of Manganese-ore in*

YEAR.	BIHAR AND ORISSA.	BOMBAY.			CENTRAL INDIA.	CENTRAL PROVINCES.					
	Gangpur.	Panch-Mahal.	Ratnagiri.	Total.	Jhabua.	Balaghat.	Bhandara.	Chhindwara.	Jubbulpore.	Nagpur.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1909 .	55,060	17,657	..	17,657	10,324	134,577	110,856	17,464	..	118,388	381,285
1910 .	41,958	30,396	525	30,921	12,664	161,987	159,164	19,556	300	211,232	552,239
1911 .	25,152	45,330	..	45,330	7,319	144,642	119,606	1,540	..	179,263	445,051
1912 .	27,173	43,538	..	43,538	5,652	135,435	115,365	16,517	..	147,225	414,542
1913 .	11,215	40,914	..	40,914	6,814	219,139	89,818	78,583	..	261,767	649,307
TOTAL .	160,558	177,885	525	178,360	42,773	795,780	594,809	188,660	300	917,875	2,442,424
Provincial averages.	*32,112*	..	..	*35,672*	*8,555*	..	..	..	..	..	*488,485*

India for the five years 1909 to 1913.

Madras.				Mysore.				Totals for whole of India.	*Totals for whole of India.*
Bellary.	Sandur.	Vizagapatam.	**Total.**	Chitaldrug.	Shimoga.	Kadur.	**Total.**		
Tons.	Tons.	Tons.	**Tons.**	Tons.	Tons.	Tons.	**Tons.**	**Statute Tons.**	*Metric Tons.*
..	78,636	59,818	**138,454**	5,856	32,717	3,307	**41,880**	**644,660**	*654,974*
500	73,666	46,441	**120,607**	1,803	40,715	..	**42,518**	**800,907**	*813,721*
..	66,950	58,915	**125,865**	..	21,573	..	**21,573**	**670,290**	*681,015*
..	62,488	54,758	**117,246**	..	24,929	..	**24,929**	**633,080**	*643,209*
..	52,169	44,127	**96,296**	..	10,501	..	**10,501**	**815,047**	*828,088*
500	333,909	264,059	**598,468**	7,659	130,435	3,307	**141,401**	**3,563,984**	*3,621,007*
..	..	..	*119,694*	..	..	..	*28,280*	*712,797*	*724,201*

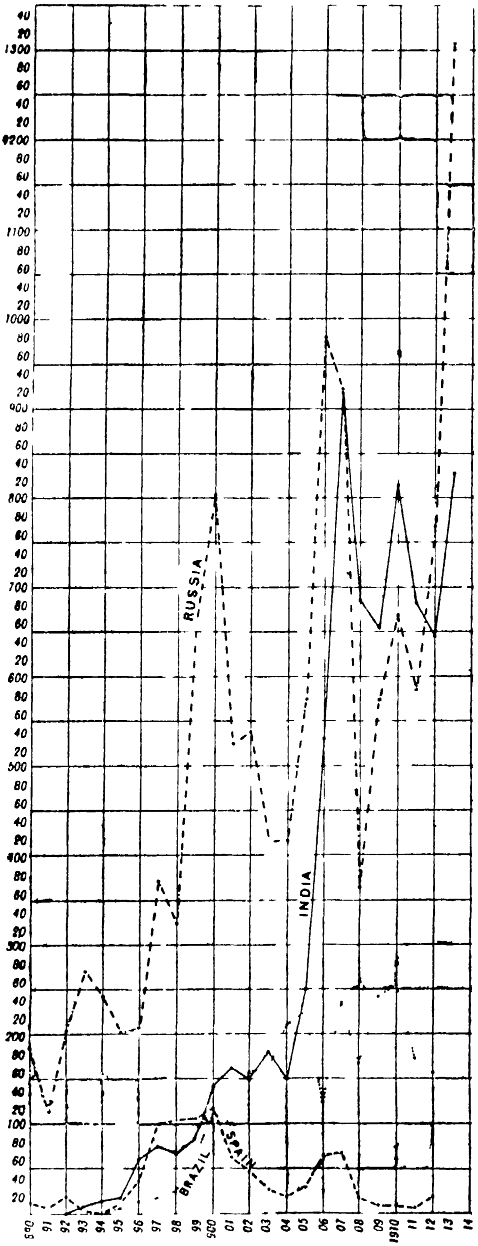


FIG. 13.—*Production of Manganese-ore in the four leading countries since 1890.*

Production of foreign countries.

The growth of the Indian manganese industry during the past five years, and its importance as compared with that of other countries, can be seen from table 58, giving the world's production of manganese-ore for the five years 1908 to 1912, and for 1913 as far as available. The figures have been compiled from various sources, chiefly the Home Office reports of the Chief Inspector of Mines, Great Britain, and the *Mineral Industry*.

From this table it will be seen that the three leading countries producing manganese-ore are Brazil, India, and Russia. In the previous quinquennium the Brazilian production remained fairly constant at an average of 195,000 metric tons annually, whilst the Indian and Russian outputs increased enormously; that of India from 152,601 metric tons in 1904 to a maximum of 916,770 metric tons in 1907; and that of Russia from 430,090 metric tons in 1904 to a maximum of 1,015,686 metric tons in 1906. In 1907 the Indian

production approached that of Russia very closely. In 1908 the Russian production fell to 362,303 metric tons, so that India, with an output of 685,135 metric tons, definitely assumed in this year the position so long held by Russia as the leading producer of manganese-ore (see fig. 13). In both countries there was, by the end of 1908, a large accumulation of stocks due to the exports during previous years falling short of the production. But this accumulation of stocks was on a much larger scale in Russia than in India.

During the present quinquennial period the Brazilian production (1909-1912) of manganese-ore increased but slightly to an annual average of 216,000 tons, whilst the Indian production fluctuated between the comparatively narrow limits of 643,209 metric tons and 828,088 metric tons with an annual average of 724,201 tons compared with an average of 516,905 metric tons for 1904-08. For the three years 1909 to 1911 India maintained her position as the leading producer, with Russia close behind, but in 1912 Russia regained her former position, increasing her lead very substantially in 1913 with the highest production yet recorded for any country in one year—namely, 1,310,000 tons. The Russian average for 1909-13 was 781,000 tons as compared with 662,000 tons for the previous period 1904-08. The Russian figures for the later period must be below the true total, because they are partly export figures, there being an internal consumption in Russia.

Production of manganiferous iron-ores.

In table 59 similar figures are given for the output of manganiferous iron-ores. According to the practice by which all ores containing less than 40 per cent. manganese are classified as manganiferous iron-ores rather than as manganese-ore, a certain, very small, proportion of the Indian production should be classed under this heading. Of the ores mined in the United States, by far the larger proportion is very low in manganese (1 to 8 per cent.).

Exports.

For comparison with the annual figures of production of manganese-ore in India, the export figures during the years 1909-10 to 1913-14 are given in table 60 stated separately for each port.

TABLE 58.—*World's Annual Production of Manganese-ore during the years 1908 to 1913.*

(Metric Tons.)

YEAR.	Austria-Hungary. (a)	Brazil. (c)	France.	Greece.	India.	Italy.	Japan.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	Other Countries.	World's Total.
1908 . .	34,232	166,122	15,865	10,750	685,135	2,750	11,130	362,303	16,945	4,668	6,409	6,665	30,595	**1,353,569**
1909 . .	35,658	240,774	9,378	5,374	654,974	4,700	8,847	574,938	7,827	5,272	2,812	1,337	24,649	**1,576,540**
1910 . .	32,964	253,953	7,925	41	813,721	4,200	11,299	668,050 (c)	8,607	5,810	5,555	2,158	21,144	**1,835,427**
1911 . .	34,309	173,911	6,036	733	681,015	3,515	9,769	584,000 (c)	5,607	5,433	5,067	2,457	4,850	**1,516,702**
1912 . .	27,954	154,870	5,576	8,082	643,209	2,641	12,052	766,000 (c)	17,400	5,163	4,237	1,664	986	**1,649,834**
1913 . .	(b)	(b)	(b)	(b)	828,088	(b)	(b)	1,310,000	(b)	(b)	5,479	4,048	(b)	..

(a) Including Bosnia and Herzegovina. (b) Figures not available. (c) Export figures.

TABLE 59.—*World's Production of Manganiferous Iron-ores from 1908 to 1913.*

(Metric Tons.)

YEAR.	Germany. (*a*)	Greece.	Italy.	United States.
1908	67,693	63,875	17,812	531,427
1909	77,177	54,926	25,830	857,228
1910	80,560	50,015	25,700	629,680
1911	87,296	26,083	6,482	530,739
1912	92,474	14,311	*Nil*	882,438
1913	(*b*)	(*b*)	(*b*)	682,932

(*a*) Includes a certain amount of true manganese-ore.
(*b*) Figures not available.

TABLE 60.—*Exports of Indian Manganese-ore from April 1st, 1909, to March 31st, 1914.*

(Statute Tons.)

YEAR.	Vizagapatam.	Bombay.	Calcutta.	Mormugao.	Yearly total.
1909-10 . . .	67,600	382,599	50,145	81,060	**581,404**
1910-11	43,200	449,488	80,291	101,053	**674,032**
1911-12	50,800	436,194	49,083	88,226	**624,303**
1912-13 . . .	54,000	581,696	72,391	78,800	**786,881**
1913-14 . .	36,750	606,724	74,575	86,747	**804,796**

From table 61, giving the total Indian production and exports for the years 1892 to 1913, it will be seen that by the end of 1913 there was an accumulation in India of over 400,000 tons of stocks, representing an increase in stocks of 93,000 tons during the present quinquennium. Judging from reports there must be a still larger accumulation of stocks of manganese-ore in the Caucasus.

TABLE 61.—*Comparison of Indian Manganese-ore Production with Exports.*

(Statute Tons.)

PERIOD.	Ore produced.	Ore exported.	Excess of production over exports.
1892 to 1903	929,145	..	..
1892-93 to 1903-04	..	916,386	12,759
1904 to 1908	2,545,718	..	..
1904-05 to 1908-09	..	2,217,596	328,122
1909 to 1913	3,563,984	..	..
1909-10 to 1913-14	..	3,471,416	92,568
TOTAL	**7,038,847**	**6,605,398**	**433,449**

Distribution of Indian manganese-ore exports.

The distribution of the manganese-ores exported from India amongst foreign countries is shown in table 62. As in the period 1904-08, the three great steel producing countries—England, Germany, and the United States—took a large proportion of the Indian manganese-ore, the exports to Holland and Belgium shown in the table being in part for transmission to Germany; but, in addition, France became an important customer, taking nearly three times as much ore as in 1904-08.

TABLE 62.—*Distribution of exported Indian Manganese-ore for the years 1909-10 to 1913-14.* (*a*)

(Statute Tons.)

YEAR.	United Kingdom.	Belgium.	France.	Germany	Holland.	Italy.	United States.	Austria-Hungary.	Japan.	Total recorded export for the year.
1909-10 .	168,053	104,935	61,715	1	16,700	..	148,940	..	..	**500,344**
1910-11 .	189,358	137,680	99,640	1	15,450	..	130,850	..	..	**572,979**
1911-12 .	138,003	148,357	107,171	7,200	29,075	..	106,271	..	.	**536,077**
1912-13 .	211,921	171,066	112,223	7,250	23,850	6,600	168,600	3,300	3,271	**708,081**
1913-14	258,776	187,821	103,847	18,950	8,200	7,800	106,327	10,310	16,018	**718,049**
TOTAL .	**966,111**	**749,859**	**484,596**	**33,402**	**93,275**	**14,400**	**660,988**	**13,610**	**19,289**	**3,035,530**

(*a*) Excludes exports *viâ* Mormugao.

Labour.

In Vizagapatam and Mysore an adequate supply of labour seems to be easily obtainable, but in the Central Provinces, Central India, the Sandur Hills, and other parts, labour has frequently to be imported. To relieve themselves of unnecessary trouble and responsibility the mine managers find it preferable to work through contractors, paying them at a given rate per 1,000 cubic feet of stacked and cleaned ore, and for dead-work at a given rate per 1,000 cubic feet of cavity made in the quarry in the case of soft 'deads,' or per 1,000 cubic feet of waste measured in tubs or stacked in the case of hard 'deads.' The daily rates paid to the coolies by the contractors vary between the following limits in different parts of India :—

	Annas.
Men	$2\frac{1}{2}$ to 7
Women	$1\frac{1}{4}$ to 4
Children	1 to 3

The average daily number of workers during the past five years is shown in table 63.

TABLE 63.—*Daily Number of Workers employed at the Manganese Quarries from 1909 to 1913.*

YEAR.	Bihar and Orissa.	Bombay.	Central India.	Central Provinces.	Madras (c)	Mysore.	TOTAL.
1909 . . .	(a)	651	477	10,947	5,451	1,698	**19,224**
1910 . . .	(a)	933	369	13,733	3,716	1,477	**20,228**
1911 . . .	(a)	1,512	271	11,054	3,900	427	**17,164**
1912 . . .	1,228	1,371	278	10,014	4,142	504	**17,537**
1913 . . .	938	1,197	361	13,918	3,547	548	**20,509**
Average .	*1,083* (b)	*1,133*	*351*	*11,933*	*4,151*	*931*	*19,582*

(a) Figures not available.
(b) Average of two years.
(c) Vizagapatam and Sandur, with Bellary in 1910.

In order to permit of the comparison of the manganese with the coal industry as regards labour, the figures appertaining only to those mines that come under the Mines Act, 1901, are given in table 64. From these figures it is seen that the average number of persons employed daily on the manganese mines under the Act has been 11,804 for an average annual output of 465,631 tons, compared with 11,135 persons and an average annual output of 383,279 tons of ore for the previous quinquennial period. The number of tons of ore won per person employed has thus increased from 34 to 39, due no doubt partly to an increase of skill and partly to an increasing use of mechanical appliances, especially for haulage. The output of coal per person employed was nearly three times the above figure (see table 30). The death-rate has been 0·63 per 1,000 persons employed as compared with 1·38 in the case of coal: these figures are somewhat higher than for the period 1904-08, when the corresponding figures were 0·34 and 0·98 respectively. At the same time the number of deaths per million tons won has increased in the case of manganese from 9·9 in 1904-08 to 15·9 in 1909-1913, compared with an increase from 10·2 to 12·8 in the case of coal.

TABLE 64.—*Labour Statistics for Manganese Mines under the Mines Act, 1901.*

YEAR.	Average number of persons employed daily.	Production.	Output per head.	Number of deaths.
		(Tons).	(Tons).	
1909	10,795	357,205	33·0	6
1910	11,347	468,669	41·3	17
1911	11,884	441,426	37·1	4
1912	11,032	423,464	38·3	3
1913	13,960	637,391	45·6	7
TOTAL	**59,018**	**2,328,155**	..	**37**
Average	*11,804*	*465,631*	*39·4*	*7·4*

Cost of mining and transport.

The chief items in the cost of placing manganese-ore on the markets in Europe and America are the following:—

1. Cost of mining (labour, tools, plant, establishment).
2. Cost of transport to the railway.
3. Cost of transport to the port of shipment.
4. Cost of handling at the port of shipment.
5. Cost of shipping to Europe or America.
6. Destination charges.

Each of these six items—the first five of which vary according to the situation of the deposit—has been considered in detail in *Memoirs, Geol. Surv. Ind.*, XXXVII, Chapter XXIII, to which the reader is referred. In table 65 below, however, an abstract is given showing the average cost of delivering *c.i.f.* at English and Continental ports, ore derived from several of the producing areas. These figures, with the exception of those for the Panch Mahals, are based on information collected prior to 1910, and should probably be slightly increased on account of increasing costs with greater

depth of working; but it is improbable that there have been any substantial variations from them except in years of exceptional high freights. The figures of most importance are those relating to Central Provinces ore exported *viâ* Bombay. For not only did 71 per cent. of the Indian manganese-ore exports for 1909-13 pass through this port, but 91 per cent. of this amount was derived from the Central Provinces, which provided 68 per cent. of the Indian production during the quinquennium. These figures are also the most accurate. It will be seen that the cost of exporting Central Provinces ore *viâ* Calcutta was considerably higher than for Bombay. This was due to heavier transport charges, owing partly to the longer railway lead to Calcutta than to Bombay, and partly to the unfavourable situation, with regard to the railways, of the Chhindwara deposits. But the close of the quinquennium has seen the opening of the Bengal-Nagpur Railway to Sausar and Ramakona, so that the Chhindwara ore is now railed to Bombay.

TABLE 65.—*Average Cost of Indian Manganese-ore delivered c.i.f. at English and Continental Ports.*

AREA FROM WHICH DERIVED.	Port from which exported.	Average cost per ton.		
		RS.	A.	P.
Central Provinces	Bombay	26	14	0
Ditto	Calcutta	31	10	0
Gangpur, Bihar and Orissa	Ditto	22	5	0
Jhabua, Central India	Bombay	22	3	0
Panch Mahals, Bombay	Ditto	26	8	0
Vizagapatam, Madras	Vizagapatam	23	7	0
Sandur, Madras	Mormugao	23	7	0
Mysore	Ditto	29	8	0

In the same Memoir some detailed figures are given of the costs of delivering Brazilian and Russian ores *c.i.f.* in London. The total costs are compared with those for Indian ore in table 66. From

this it will be seen that with low rates of exchange the Brazilian ores can compete on equal terms with those of India and Russia, but with high rates of exchange Brazilian ores are at a considerable disadvantage. Comparing the Indian and Russian ores it is seen that the Vizagapatam ores cost less to deliver in London than the ores of the Central Provinces and Russia, and that the two latter cost about the same. Assuming the foregoing figures to represent

TABLE 66.—*Comparison of Cost of delivering Brazilian, Russian, and Indian Manganese-ore c.i.f. at London.*

—	BRAZIL (Mines Geraes). (*a*)		RUSSIA (Caucasus).		INDIA.	
	At 1,000 milréis = 7 annas.	At 1,000 milréis = 14 annas.	According to Demaret(*b*) (1905).	According to Drake (*c*) (1898).	Central Provinces *viâ* Bombay.	Vizagapatam.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Rupees . .	22 15 11	35 9 10	26 9 0	29 6 0	27 4 0	23 11 0
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
Sterling . .	1 10 8	2 7 6	1 15 5	1 19 2	1 16 4	1 11 7
Price per unit at which the ore would be sold at no profit or loss.	7·36*d.*	11·4*d.*	8·5*d.*	9·4*d.*	8·7*d.*	8·2*d.*

(*a*) After Demaret, *Annales des mines de Belgique*, X, p. 843, (1905).
(*b*) *Loc. cit.*, p. 886.
(*c*) *Trans. Am. Inst. Min. Eng.*, XXVIII, p. 207, (1898).

the average cost fairly, and assuming all the ores to be first-grade, containing 50 per cent. manganese, except the Vizagapatam ore which is assumed to average 46 per cent. Mn and fetches second-grade prices, then the figures given in the last line in table 66 show the price per unit at which the ore would be sold at neither profit nor loss. Since the Russian and Indian ores make up a very large proportion of the world's total production, it follows from these figures that the price per unit of first-grade ore can never fall below

about 8½ to 9 pence without automatically so restricting production and export of ores as quickly to send the price back to this level. This is well seen by studying the prices prevailing during 1908 and 1909. By the close of 1908 the price of first-grade ore had fallen to 9¼*d.*, and mining of manganese-ore was in consequence enormously diminished. At the beginning of March 1909 the price declined further to 9 pence per unit. By October the effects of the increasing activity in the steel-trade and the lessened supplies of manganese-ore were felt and the price rose again to 9½*d.*, with an upward tendency for the lower grade ores also.

Royalties.

In British India the royalty leviable on the base metals is—

'2½ per cent. on the sale value at the pit's mouth, or on the surface, of the dressed ore or metal, convertible at the option of the Local Government to an equivalent charge per ton to be fixed annually for a term.'

Since it is inconvenient and very difficult to assess the royalties separately for each deposit and producer, it is customary in each area to assume average figures for the composition of the ore and for the costs of mining, transport, etc., and to apply them without distinction to all cases. Table 67 shows a sliding scale of royalties first drawn up for the Central Provinces by agreement between the local administration and the mining community. This scale has also been adopted for Bombay, and Bihar and Orissa. In applying this table the average price for a period of a year should be used.

TABLE 67.—*Royalties, in Annas per Ton, leviable on Manganese-ore extracted in the Central Provinces, Bombay, and Bihar and Orissa.*

Price per unit of first-grade ore.	Royalty leviable per ton of ore.
Pence.	*Annas.*
8	½
9	1
10	1½
11	2
12	3
13	4
14	5
15	7
16	9
17	11
18	13

In the Native States a fixed royalty irrespective of price is usually arranged when a prospecting license or mining lease is granted. The rates prevailing in certain States are as follows :—

TABLE 68.—*Royalty, in annas per ton, levied in certain Native States and Zamindari lands.*

	Annas.
Jhabua State, Central India	4
Mysore State [1]	6+2½ per cent. on profits over 10 per cent. of capital.
Sandur State, Madras	6
The Vizianagram Samasthanum, Madras	4

Valuation of manganese-ores.

From table 56 and the diagram (fig. 12) on page 138, it will be seen that the price per unit of manganese, and consequently the price per ton of manganese-ore obtained on its delivery *c.i.f.* at the port of destination, is subject to great variations. The prices given in the table are for the three grades into which manganese-ores are, for commercial purposes, classified. Up till November 1909 (*Mining Journal*) the following classification was in use :—

1st grade	50 per cent. Mn and upwards.
2nd „	47—50 per cent. Mn.
3rd „	40—47 per cent. Mn.

But from December 1909 the following schedule has been employed :—

1st grade	50 per cent. Mn.
2nd „	48—50 per cent. Mn.
3rd „	45—48 Mn.

[1] This rate appears to have been changed in 1910 to a royalty of 6 annas per ton when the market price was 9*d*. or under, with a sliding scale for higher prices : and this scale was superseded on 1st July 1912 by the following scale based on average market price in London for 50 per cent. ore :—

Price per unit.	*Royalty per ton.*
9*d*. and under.	1 anna.
9*d*. to 10*d*.	2 annas.
For each additional 1*d*. or fraction thereof.	An additional 2 annas.

As an example of the way in which the schedule of prices is applied we can take the case of a 52 per cent. ore from the Central Provinces in January 1910. The average price at this time was $9\frac{1}{2}$ pence per unit. The price then paid per ton for this ore would be $\frac{52 \times 9\frac{1}{2}}{12}$ = £2-1-2.

The prices quoted in the *Mining Journal* and given in table 56, apply of course to ore delivered in the United Kingdom; and for this scale to be applicable it was formerly necessary that the ore should not contain more than 10 per cent. of silica and 0·10 per cent. of phosphorus.

Schedule of the Carnegie Steel Company.

In the United States a schedule of prices is fixed periodically by the Carnegie Steel Company. The schedule given in the 'Mineral Industry' for 1912 is as follows:—

Over 49 per cent. of Mn.	26 cents
46—49 per cent. of Mn.	25 ,,
43—46 per cent. of Mn.	24 ,,
40—43 per cent. of Mn.	23 ,,

and is based on ores containing not more than 8 per cent. silica or 0·2 per cent. phosphorus. Deductions are made from the price of the ore of 15c. per ton for each 1 per cent. of silica in excess of 8 per cent. and of 2c. per unit of manganese for each 0·02 per cent. of phosphorus in excess of 0·2 per cent.

Ore containing less than 40 per cent. of manganese, or phosphorus in excess of 0·225 per cent., or silica in excess of 0·12 per cent., is subject to acceptance or refusal at the buyer's option. An additional price (5 to 6 cents, according to market) per unit of iron present in the ore is sometimes paid by the steel-makers; but the practice as regards this constituent varies. Settlements are based on the analysis of samples dried at 212° F., the moisture being deducted from the weight of the ore.

Requirements made less stringent during 1906.

It is probable that a considerable proportion of the restrictions on the quality of manganese-ores imposed by steel-makers are not always closely connected with metallurgical difficulties in the treatment of the ores, but with the desire of the steel-makers to obtain their supplies of manganese-ore at as favourable a price as possible, and to be able to cut down the prices paid whenever possible by levying fines for the presence of

a small percentage of a given constituent in excess of what is stated in their schedule of prices. That this is probably the true interpretation of the situation is shown by the fact that whereas the free phosphorus limit in the Carnegie Steel Company's schedule was 0·10 per cent. in 1905 it has since been raised to 0·20 per cent., whilst during 1906, under the influence of the great demand for Indian ores, it seems to have been possible to find a market for almost every variety of ore that could be obtained, except the very siliceous ones. There has for some years been a steady demand for the ores of Vizagapatam ranging in phosphorus from 0·25 to 0·45 per cent., and for the Jhabua ores averaging 0·20 per cent. of phosphorus. During 1905 and 1906 a market was also found for Vizagapatam ores containing between 30 and 40 per cent. of manganese; and during 1907 some of the ores from Shimoga in Mysore, for which a market was found, ran as low as 30 per cent. in manganese. The constituent that seems to be of much more importance than the phosphorus as a deleterious constituent is the silica, and we have not heard of any contracts made for the supply of Indian manganese-ores containing over 10 per cent. of this constituent. The influence of the steady supply of high-grade manganese-ores assured by the entry of Brazil and India into the market has at last made itself felt and doubtless caused the change in classification in 1909 noted on page 153.

Valuation for chemical purposes.

The prices noticed above are those relating to manganese-ores intended for use in the iron and steel industry. For ores suited for use in the chemical industries as oxidising agents much higher prices are often obtained. For chemical purposes it is not the percentage of manganese that is of importance, but the percentage of oxygen liberated on treating the ore with acid, *i.e.*, the *available oxygen*. This is usually expressed in terms of the percentage of manganese peroxide, MnO_2. Not only does the percentage of MnO_2 affect the price, but also the ease with which the oxygen is liberated. Further, impurities that are soluble in acid, and so cause an unnecessary consumption of it, are deleterious. The best minerals for these purposes are pyrolusite, psilomelane, and hollandite. For the glass industry the ore must be as free as possible from iron. The only Indian pyrolusite yet found sufficiently pure for the glass industry is that of Pali in the Nagpur district. A picked specimen of this giving 95·57 per cent. MnO_2 showed only 0·06 per cent. Fe_2O_3. To

show the high prices given for ores sold for their percentage of peroxide, the following figures are quoted from the *Engineering and Mining Journal* for August 3rd, 1907, page 236; they refer to crude powdered ore.

TABLE 69.—*Prices of Manganese-ores sold for Peroxide.*

Percentage of MnO_2.	Cents per pound.	Equivalent sterling price per ton.
		£ *s.* *d.* £ *s.* *d.*
70—75	1¼—1½	5 16 8 to 7 0 0
75—85	1½—2	7 0 0 to 9 6 8
85—90	1¾—5	8 3 4 to 23 6 8
90—95	6½	£30-6 8

The price is sometimes as high as 20c. per lb. Japanese ores sold at Hamburg fetch prices ranging from £2-10-0 to £5-15-0 per ton according to quality (*Mineral Industry* for 1910, p. 473).

Nomenclature of manganese-ores and manganiferous iron-ores.

It is customary to divide the ores of iron and manganese into iron-ores, manganiferous iron-ores, and manganese-ores. The least percentage of manganese in an iron-ore that is usually paid for is said to be 5 per cent., and with less than 5 per cent. of manganese it hardly seems necessary to prefix the adjective 'manganiferous.' The dividing line between manganiferous iron-ores and manganese-ores was formerly taken at 44 per cent. manganese (=70 per cent. MnO_2). Later, ores with as little as 40 per cent. manganese have been termed manganese-ores, and those below this limit manganiferous iron-ores. According to this method one often sees an ore referred to as manganiferous iron-ore that contains much more manganese than iron. Such a difficulty can easily be avoided by creating a class for *ferruginous manganese-ores.* Accordingly, in *Memoirs, Geol. Surv. Ind.*, XXXVII, page 500, (1909), the following classification has been proposed. It is applicable to all ores containing over 50 per cent. of Mn + Fe.

—	Mn per cent.	Fe per cent.
Manganese-ores	40—63	0—10
Ferruginous manganese-ores	25—50	10—30
Manganiferous iron-ores	5—30	30—65
Iron-ores	0—5	45—70

Analyses of manganese-ores.

On pages 501 to 509 of the work cited above a series of tables of analyses of Indian ores will be found. A good idea as to the quality of the ores obtained in different parts of India can be gleaned from the range and mean values of these analyses summarised in the two tables (70 and 71).

Analyses of Indian ores expected by buyers.

For comparison with the figures given in table 70 we give in table 72 figures, obtained from a reliable source, showing the range in the composition of the ores that buyers expect to obtain when contracting for the purchase of various Indian ores. It will be seen that they agree wery well, with one or two exceptions, with the figures given in table 70. The most marked exception is the Panch Mahals. The figures given in table 70 relate to outcrop samples taken without any selection, such as would naturally take place when the ores were worked; and we have recently ascertained that the average quality of ore as exported is manganese 48·5 per cent., silica 7·4 per cent., and phosphorus 0·17 per cent.

Analyses of cargoes of Indian and foreign ores landed at Middlesborough.

In order to show the value of the Indian ores relative to those of foreign countries two tables (73 and 74) are given below showing the limits and averages, respectively, of a large number of cargoes of manganese-ores and manganiferous iron-ores landed during the years 1897-1906 at Middlesborough. They represent not only Indian manganese-ores, but also the manganese-ores of the Caucasus, Brazil, and Chile, and the manganiferous iron-ores of Greece and Spain (*viâ* Carthagena). From these figures it will be seen that the Indian ores contain less moisture than those of the other countries. Some of the latter contain such large quantities of moisture—Caucasus,

TABLE 70.—*Range of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	BENGAL.		BOMBAY.					CENTRAL INDIA.	CENTRAL PROVINCES.		
DISTRICT.	SINGHBHUM.		BELGAUM. (a)		DHARWAR (SANGLI).(b)	PANCH MAHALS.	SATARA.	JHABUA.	BALAGHAT.	BHANDARA.	CHHINDWARA.
Class of ore.	Manganese-ore.	Manganiferous iron-ore.	Manganese-ore (some ferruginous).	Manganiferous iron-ore.	Ferruginous manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.
Number of analyses.	3	3	10	2	10	4	4	5	13	13	9
Manganese .	46·89—48·08	4·23—20·66	31·20—60·85	8·34—12·84	19·45—38·48	30·20—49·35	37·58—45·62	44·29—48·49	49·08—54·51	49·00—54·07	48·95—54·97
Iron . .	1·22— 6·10	25·60—41·30	0·10—18·38	47·22—51·88	13·3 —25·3	3·05— 6·25	4·40— 9·25	5·86—10·40	5·28— 9·10	3·86—10·25	5·00—11·77
Silica . .	2·45— 8·30	14·70—18·10	0·65— 2·50	1·85— 2·70	7 —31	2·80—40·65	2·90— 4·75	5·85—11·25	1·62— 6·02	2·08— 6·50	4·98—10·63
Phosphorus .	0·27— 0·42	0·35— 1·18	0·01— 0·12	0·02— 0·025	..	0·16— 0·25	0·04— 0·10	0·165— 0·27	0·04— 0·24	0·06— 0·34	0·06— 0·28
Moisture .	0·55— 0·88	1·00— 1·40	..	..	..	0·30— 0·40	1·70— 2·50	0·20— 0·75	0·12— 0·85	0·09— 1·00	0·00— 1·27

(a) From analyses, by Messrs. Pearson of London, supplied by Mr. C. Aubert.
(b) From analyses, by Major Collis Barry, supplied by the Bombay Company, Ltd.

TABLE 70 (contd.)—*Range of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India*—continued.

PROVINCE.	CENTRAL PROVINCES—*contd.*				MADRAS.					MYSORE.		
DISTRICT.	NAGPUR.	JUBBULPORE.			GANJAM.	SANDUR. (a)	VIZAGAPATAM.			SHIMOGA. New Mysore Manganese Company. (b)		SHIMOGA. Shimoga Manganese Company. (c)
Class of ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.	Ferruginous manganese-ore.	Manganese-ore and ferruginous manganese-ore.	Manganese-ore and ferruginous manganese-ore.	Supplied by Vizianagram Mining Company. Manganese-ore.	Supplied by Vizianagram Mining Company. Ferruginous manganese-ore.	Manganese-ore. Higher grade.	Manganese-ore. Lower grade (ferruginous).	Manganese-ore and ferruginous manganese-ore.
Number of analyses.	30	3	7	4	1	6	12	8	7	..	..	9
Manganese	42·28—56·52	34·53—56·80	6·20—25·60	0·16— 1·70	28·44	39·47—54·39	32·21—49·05	41·45—49·69	35·43—38·51	44—56	30—44	34·51—55·94
Iron	2·09—16·34	1·60—10·30	19·17—47·10	42·08—59·90	19·70	5·38—19·40	4·80—15·70	2·35—12·90	12·87—19·32	2—10	10—20	4·01—17·25
Silica .	2·90—18·48	1·40— 4·79	4·40—23·40	5·21—20·40	10·25	0·43— 1·00	1·10—10·30	3·05— 5·70	4·93— 6·90	1—3	2—6	0·22— 5·75
Phosphorus	0·04— 0·65	0·03— 0·46	0·02— 0·85	0·04— 0·48	0·71	0·02— 0·03	0·13— 0·48	0·26— 0·45	0·20— 0·45	0·15—0·06	0·01—0·06	0·01— 0·14
Moisture .	0·11— 1·32	0·39— 0·90	0·12— 0·65	0·2[illegible]— 0·38	2·55	..	0·50— 1·85	..	..	about 1	about 1	..

(a) From analyses, supplied by Mr. C. Aubert.
(b) Estimated figures by Mr. C. S. Fawcett.
(c) From analyses, by various chemists, supplied by Miss A. E. Dawson.

TABLE 71.—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the various Districts and Provinces of India.*

PROVINCE.	BENGAL.		BOMBAY.					CENTRAL INDIA.	CENTRAL PROVINCES.						
DISTRICT.	SINGHBHUM.		BELGAUM.		DHARWAR (SANGLI).	PANCH MAHALS.	SATARA.	JHABUA.	BALAGHAT.	BHANDARA.	CHHINDWARA.	NAGPUR.	JUBBULPORE.		
Class of ore.	Manganese-ore.	Manganiferous iron-ore.	Ferruginous manganese-ore.	Manganiferous iron-ore.	Ferruginous manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.
Number of analyses.	3	3	10	2	10	4	4	5	13	13	8	30	3	7	4
Manganese . .	47·66	11·84	44·77	10·53	31·62	41·68	40·79	46·94	51·88	51·94	52·72	51·53	45·56	20·26	0·96
Iron . . .	2·90	34·93	10·33	49·55	16·8	4·07	6·94	8·44	7·40	7·27	7·08	6·24 (29/30)	4·79	28·78	50·50
Silica . . .	4·63	16·46	1·40	2·27	19·1	19·11	3·75	8·14	3·74	4·59	7·16	7·25	2·68	12·99	10·76
Phosphorus . .	0·34	0·74	0·035	0·023	..	0·20	0·07	0·20	0·11	0·14	0·14	0·11	0·215	0·25	0·32
Moisture . .	0·63	1·17	..	..	..	0·35	1·99	0·43	0·37	0·44	0·38	0·49 (28/30)	0·56	..	0·33
Manganese + Iron .	50·56	46·77	55·10	60·08	48·42	45·75	47·73	55·38	59·28	59·21	59·80	57·77	50·35	49·04	51·46

TABLE 71 (contd.).—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the various Districts and Provinces of India*—continued.

PROVINCE.	MADRAS.					MYSORE.		
						SHIMOGA.		
DISTRICT.	GANJAM.	SANDUR.	VIZAGAPATAM.			New Mysore Manganese Company.		Shimoga Manganese Company.
				Supplied by Vizianagram Mining Company.		Ferruginous manganese-ore.		
Class of ore.	Ferruginous manganese-ore.	Ferruginous manganese-ore.	Ferruginous manganese-ore.	Manganese-ore.	Ferruginous manganese-ore.	Higher grade.	Lower grade.	Manganese ore.
Number of analyses.	1	6	12	8	7	3	Half the limits.	9
Manganese . . .	28·44	47·75	42·96	44·34	36·75	46·75	37	49·10
Iron . . .	19·70	11·45	11·22	9·08	15·20	10·06	15	7·74
Silica	10·25	0·61	4·29	4·15	5.72 (?)	1·77	[illegible]	2·62
Phosphorus . . .	0·71	0·030	0·27	0·32	0·335	0·031	0·035	0·085
Moisture . . .	2·55	..	0·90	.	..	0·95	1	..
Manganese + Iron . .	48·14	59·20	54·18	53·42	51·95	56·81	52	56·84

8·67 per cent.; Brazil, 11·35 per cent.; and Spain, 8·44 per cent.—that it is necessary to reduce the analyses to their condition when dried at 100° C. before any fair comparison can be made. This has been done by assuming that the constituents of the ores not given in the 'as received' columns would if determined make the analyses add up exactly up to 100. From the figures representing the dried ores it will be seen that the Indian ores stand first as regards manganese contents, with Brazil a close second: as regards silica, Brazil stands first, with India second: as regards phosphorus, however, India stands last but one, the only ores containing more phosphorus being those of Russia: the Indian ores contain much less iron than the manganiferous iron-ores of other

TABLE 72.—*Analyses of Indian Manganese-ores for which Buyers stipulate when making contracts.*

PROVINCE.	BOMBAY.	CENTRAL INDIA.	CENTRAL PROVINCES.				MADRAS.		MYSORE.
DISTRICT.	PANCH MAHALS.	JHABUA.	NAGPUR, BALAGHAT, AND BHANDARA.	NAGPUR AND BHANDARA.		NAGPUR.	SANDUR.	VIZAGAPATAM.	SHIMOGA.
Shipping firms.	Shivrajpur Syndicate, Ltd.	Kiddle, Reeve & Co.	Central Provinces Prospecting Syndicate.	Central India Mining Company, Ltd.		Indian Manganese Company, Ltd.	Jambon & Co.	Vizianagram Mining Company, Ltd.	Mysore Manganese Company, Ltd., and the Madras Mining Syndicate.
				First grade.	Second grade.				
Manganese	51 —52	46 —48	52 —54	51 —52	46 —48	50 —52	44 —46	45 —47	46 —47
Iron	6 — 8	4 — 7	4 — 6	6 — 7	6 — 8	5 — 6	13 —16	12 —14	9 —10
Silica	5 — 6	8 — 9	6 — 7	7 — 8	9 —11	6 — 8	2 — 4	3 — 4	3 — 4
Phosphorus	0·17— 0·18	0·13— 0·16	0·07— 0·08	0·09— 0·11	0·13— 0·17	0·11— 0·14	0·05— 0·06	0·26— 0·33	0·04— 0·05

countries; but of the true manganese-ores they contain the highest amounts of iron, in spite of the fact that they also contain the highest amounts of manganese. The high iron contents of the Indian ores may be regarded as a point in their favour, or otherwise, according to the use to which the ores are to be applied. It is true that the high iron contents make it more difficult to manufacture the very highest grades of ferro-manganese from the Indian ores; but, on the other hand, if the very highest grades are not required, then the iron is of considerable value. Both manganese and iron are of use in this case, and the buyer obtains the following totals of Mn + Fe when he buys the ores of the different countries :—

	Mn+Fe. Per cent.
India	57·17
Brazil	54·09
Russia	50·41
Chile	48·40
Greece	47·99
Spain	44·27

As regards phosphorus, the figures for the Indian ores are rather misleading; for an examination of the analyses from which these figures have been taken shows that the ores consist of two different varieties. The majority of analyses are typical of the ores of the Central Provinces, whilst four of them probably represent ores from the Vizagapatam district. I have accordingly separated them into two groups, of which the mean values are given in table 75. From these figures it will be seen that the Central Provinces ores average 0·096 per cent. and the Vizagapatam ores 0·291 per cent. in phosphorus.

Value of the Indian manganese-ore production.

The valuation of the Indian manganese-ore production is a question of some interest. There are of course several ways of stating the value. Manganese-ore possesses one value per ton as stacked at the pit's mouth, another as delivered *f.o.r.* at the railhead, a third as delivered *f.o.b.* on board the ship at the port of shipment, a fourth as delivered *c.i.f.* at the port of destination, and a fifth after it has been converted into ferro-manganese. For example, with the price at fourteen pence per

TABLE 73.—*Limits of Analyses of Cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesborough during the ten years 1897 to 1906.*

COUNTRY.	INDIA.	RUSSIA (CAUCASUS).	BRAZIL.	CHILE.	GREECE.		SPAIN (*viâ* CARTHAGENA).
Class of ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ores.		Manganiferous iron-ores.
					Raw.	*Calcined.*	
Number of cargoes.	26	77	25	9	54	18	24
Period.	1900—1906.	1898—1906.	1898—1906.	1898—1903.	1897—1906.	1897—1903.	1897—1905.
Manganese . .	42·13 —54·53	40·74 —48·98	37·05 —48·14	46·44 —49·56	8·63 —24·44	10·41 —23·21	7·32 —21·78
Iron . . .	3·85 —11·69	0·38 — 0·93	2·55 — 8·26	0·25 — 0·52	18·96 —42·75	26·55 —43·75	16·38 —40·75
Silica . . .	2·63 — 9·99	6·91 —13·06	0·80 — 7·78	6·12 — 9·16	2·59 —11·52	5·35 — 9·70	6·50 —17·97
Phosphorus . .	0·056— 0·331	0·095— 0·17	0·017— 0·130	0·009— 0·018	0·012— 0·044	0·015— 0·038	0·007— 0·022
Moisture . .	0·21 — 2·64	5·67 —12·35	2·69 —19·57	0·54 — 2·13	0·56 — 8·74	..	4·07 —13·78
Alumina, siliceous matter, etc.	3·63 —13·18	8·97 —15·58	0·92 —12·80	11·92 —13·47	2·74 —12·13	6·20 —10·80	6·18 —19·52

TABLE 74.—*Mean of Analyses of Cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesborough during the ten years 1897 to 1906.*

COUNTRY.	INDIA.		RUSSIA. (CAUCASUS).		BRAZIL.		CHILE.		GREECE.			SPAIN (*viâ* CARTHAGENA).	
Class of ore.	Manganese-ore.		Manganese-ore.		Manganese-ore.		Manganese-ore.		Manganiferous iron-ores. *Raw.*		Manganiferous iron-ores. *Calcined.*	Manganiferous iron-ores.	
Number of cargoes.	26		77		25		9		54		18	24	
Period.	1900—1906.		1898—1906.		1898—1906.		1898—1903.		1897—1906.		1897—1903.	1897—1905.	
Method of reporting analysis.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	As received	Dried at 100° C.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	Dried at 100° C.	As received.	Dried at 100° C.
Manganese	50·49	50·86	45·28	49·58	44·60	50·314	47·51	47·99	16·15	16·96	43·01	19·35	21·13
Iron	6·26	6·31	0 76	0·83	3·35	3·78	0·41	0·41	29·54	31·03	41·32	21·19	23·14
Silica	5·67	5·71	9 29	10 17	1·81	2·04	7·26	7·33	7·37	7·74	7·33	11·18	12·21
Phosphorus . . .	0·126	0·127	0·147	0·161	0·040	0·052	0·015	0·011	0·022	0·023	0·023	0·013	0·014
Moisture	0·72	..	8·67	..	11·35	..	1·01	..	4·79	..	..	8·44	..
Alumina, siliceous matter, etc.	6·75	6·80	11·66	12·77	2·73	3·08	12·52	12·65	8·04	8·44	8·35	12·63	13·79

Table 75.—*Mean of Analyses of Indian Ores in Table 73 arranged according to Probable Source.*

Source of ore.	Central Provinces, and possibly Jhabua and Panch Mahals.	Vizagapatam.
Number of cargoes.	22	4
Manganese	51·31	45·95
Iron	5·53	10·29
Silica	6·13	3·10
Phosphorus	0·096	0·291
Moisture	0·71	0·76

unit, the average value of Central Provinces ore may be taken as :—

Rs.	A.	
19	10	at the pit's mouth.
21	2	*f.o.r.*
30	12	*f.o.b.*
43	12	*c.i.f.*

The question of values is discussed at length in *Memoirs, Geol. Surv. Ind.*, Vol. XXXVII, Chapter XXV, and it is there shown that to obtain a true idea of the value of the industry to India the export or *f.o.b.* values must be considered. But it is also pointed out that the true value of the ore in the world's markets is the *c.i.f.* value. The export values formerly given were obviously much too low ; they were based on figures supplied by the mine operators, and represented, apparently, the cost of winning the ore and placing it on board a ship at the port, and not the true value of the ore, which is the *c.i.f.* value *minus* charges incurred from the port of shipment to the port of destination. In the work already cited the export values have been re-calculated from the beginning of the industry. First the *c.i.f.* values per ton have been calculated separately for each area, on the basis of the average market price per unit of manganese-ore during the year, and an assumed average composition of the ores. From these *c.i.f.* values the *f.o.b.* values are obtained by deducting Rs. 14 from the *c.i.f.* value per ton. The *f.o.b.* value

per ton is then multiplied by the actual production for the year. The figures thus calculated for the years 1909 to 1913 are given in table 76.

Usually the amounts of ore won and exported are not very different; but during some years, as in 1907 and 1910, the amounts of ore won exceed greatly the amounts of ore exported and the totals obtained as above are considerably more than the total values actualy obtained by the mining community. As figures for the amounts of ore exported are not obtainable in detail province by province the totals may be adjusted for these years by valuing the exports for the calendar years ending 31st December at the average value per ton derived from the total production. Treated in this way the total values for 1909 to 1913 become—

	£
1909	515,260
1910	729,312
1911	621,277
1912	972,066
1913	1,276,465

and these figures have been used in the table of total values (table 1, page 9).

Comparing the export values of the manganese-ore production with the values for the other chief Indian mineral products given in table 1 it will be seen that manganese has been displaced by petroleum from third to fourth place.

TABLE 76.—*Export values f.o.b. at Indian Ports of the Manganese-ore produced in India in the years 1909 to 1913.*

Year.	Bihar and Orissa.	Bombay.	Central India.	Central Provinces.	Madras.	Mysore.	TOTALS.	Totals Sterling.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	£
1909 .	812,135	260,441	107,112	6,052,899	1,367,233	458,793	9,058,613	**603,908**
1910 .	618,880	483,202	168,589	9,316,933	1,537,738	616,511	12,741,853	**849,457**
1911 .	378,856	682,783	91,030	7,232,077	1,494,646	293,932	10,173,324	**678,222**
1912 .	562,141	900,692	100,323	9,145,833	2,000,510	556,567	13,266,066	**884,404**
1913 .	242,524	884,765	126,911	14,974,642	1,727,309	209,364	18,165,515	**1,211,034**
TOTAL .	**2,614,536**	**3,211,883**	**593,965**	**46,722,384**	**8,127,436**	**2,135,167**	**63,405,371**	**4,227,025**
Average	*522,907*	*642,377*	*118,793*	*9,344,477*	*1,625,487*	*427,033*	*12,681.074*	*'45,405*

Other economic considerations.

On reviewing the course of the manganese industry in India during the past five years, it becomes evident from a study of the production figures (table 57) that it has attained the position of a stable and established industry. No fresh areas for manganese-ore deposits of importance were discovered, nor have any important new deposits been located in areas already under exploitation; many of the smaller and poorer deposits have been abandoned, but systematic steady work has been pursued in the case of the more important deposits. The quarries have been in many cases considerably deepened and every preparation has been made to continue work on open-cast lines; and it is apparently regarded as preferable to spend considerable sums on the dead-work of stepping back the excavations rather than to embark on the difficulties of underground work, an enterprise which amongst other things will require the training of the coolies in new and unaccustomed methods; indeed, as far as we are aware, there is at present no proposal afoot to work any of the Indian deposits by underground mining methods. In a few cases deposits have been abandoned owing to the exhaustion of easily-won ore, and no boring has been undertaken to determine whether or not such deposits continue in depth, nor is such expenditure likely to be incurred as long as large quantities of ore are obtainable from surface workings. It is indeed an indication partly of confidence in the future prospects of the deposits, but also of lack of curiosity and enterprise on the part of the directorates of manganese-mining companies, that in no case has it been considered desirable to incur the relatively small expenditure required to acquire valuable information concerning the extension of the deposits in depth.

With reference to quality it is to be noted that such information as is available points to a very slight decrease in the quality of the ore with depth, taking the form of a slight decrease in the manganese contents and a slight increase in the silica and phosphorus contents of the ore. This is probably an index of a certain amount of surface modification of the ores; but there is at present no reason for supposing that this slight deterioration will necessarily be progressive with depth.

In the previous Review reference was made to the waste of smalls and low-grade ores in the Central Provinces, and attention was drawn to the desirability of stacking the latter separately

from the waste. From enquiries made it appears that two of the principal companies operating in the Central Provinces are now following this suggestion, whilst a market has been obtained for smalls down to the size of a small walnut. Very small ore proves to be of low grade, and is either stacked with low-grade ores, or regarded as waste. Low-grade ore that occurs separately in the mines is not at present quarried.

The potential loss that India suffers through exporting its manganese-ore in the raw condition, instead of manufacturing at least a portion of it into ferro-manganese, has already been referred to in previous reviews. Although the question of manufacturing this commodity in India has, in the last few years, received some attention from business men, nothing tangible has yet resulted. The feasibility of such a project is considered at some length in *Memoirs, Geol. Surv. Ind.*, Vol. XXXVII, Chapter XXVIII, pages 584—590, (1909).

Geological Relations of Indian Manganese-ores.

The manganese industry has now assumed such importance in India that it is proposed to give below a brief sketch of the distribution and mode of occurrence of the Indian deposits. The deposits of economic value can be divided into three main groups.

(*A*) Deposits associated with a series of manganiferous intrusives known as the *kodurite* series. Found in—

Madras :—Ganjam, *Vizagapatam.*

(*B*) Deposits associated with rocks of Dharwar age—the manganiferous facies of which is known, when containing spessartite-garnet, as the *gondite* series. Found in—

Bihar and Orissa :—*Gangpur.*

Bombay :—Narukot, *Panch Mahals.*

Central India :—*Jhabua.*

Central Provinces :—*Balaghat, Bhandara, Chhindwara, Nagpur,* and Seoni.

(*C*) Deposits occurring as *lateritoid* replacement masses on the outcrops of Dharwar rocks. Found in—

Bihar and Orissa :—*Singhbhum.*

Bombay :—Dharwar, North Kanara, Ratnagiri.

Central Provinces :—*Jubbulpore.*

Goa.

Madras :—*Bellary, Sandur.*

Mysore :—*Chitaldrug, Kadur, Shimoga, Tumkur.*

Italics denote that ore has been worked for export.

In addition to the occurrences noted above, ore has been worked in the low-level laterite of Goa and the high-level laterite of Belgaum (though this occurrence—Talevadi—might perhaps be more accurately classed with the lateritoid occurrences). Manganese-ores have also been found in many other districts in India, but none of these other occurrences have been shown to be of any value. Amongst them, the following may be mentioned:—

In Bijawar rocks:—Dhar, Gwalior, Indore, Hoshangabad.
In Vindhyan rocks:—Bhopal.
In Kamthi rocks:—Yeotmal.
In Lameta rocks:—Dhar, Indore, Nimar.
In lateritic soil on the Deccan Trap:—Satara.

Each of the three chief groups will now be considered in turn.

A.—The Kodurite Group.

Kodurite series.

The kodurite series [1] is developed typically in the Vizagapatam district, where it occurs associated with other Archæan crystalline rocks, the chief groups of which are the khondalite series including the calcareous gneisses, the gneissose granite, and the charnockite series. The kodurite series is held to be of igneous origin, and probably of later age than the khondalite series, which is the series with which it is closest associated. The original koduritic magma has been differentiated into a series of rocks ranging from very acid (quartz-orthoclase-rock) through basic (kodurite) to ultra-basic (spandite-rock and manganese-pyroxenites). The typical rock, *kodurite*, is composed of potash-felspar, spandite (a garnet intermediate in composition between spessartite and andradite), and apatite. The manganiferous nature of these koduritic rocks has been a petrological surprise, and a suggestion has recently been advanced [2] that they may be hybrid rocks produced by the assimilation by an acid igneous magma of manganese-ore bodies and manganese-silicate-rocks allied perhaps to the gondite series.

The manganese-bearing minerals contained in these rocks are spandite, rhodonite, and two or three other manganiferous pyroxenes,

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, Chaps. XII, XIII, (1909); *Rec. Geol. Surv. Ind.*, XXXV, p. 22, (1907); *op. cit.*, XLII, p. 208, (1912); *op. cit.*, XLIII, p. 42, (1913).
[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLV, p. 102, (1915).

at present unnamed. Subsequently, the whole series of rocks has been chemically very much altered with the production from the felspar of enormous masses of lithomarges and, from the manganiferous silicates, of manganese-ores. Other secondary products are chert, ochres, and wad.

Vizagapatam: mode of occurrence.

The manganese-ore bodies thus formed are often extremely irregular both in shape and size, often showing no definite strike or dip. But in other cases, as at Garbham, the ore-bodies have a well-marked dip and strike, and apparent bedding, which probably represents original banding in the parent rock ; for much of the ore has been deposited so as to replace metasomatically the pre-existing rock.

Dimensions of ore-bodies.

Some of the ore-bodies are of very large size. The largest, Garbham, is some 1,600 feet long, and 167 feet thick at its thickest section, 100 feet of this thickness being ore and the remainder lithomarge, wad, etc. From the commencement of work on this deposit in 1896 to the end of 1913, Garbham has yielded the enormous total of 736,192 tons of ore. The only other very large deposit in this district is Kodur ; but this is really a series of scattered ore-bodies in lithomarge. It has yielded 370,382 tons of ore from 1892 to 1913. It was the first manganese-ore deposit to be worked in India.

Composition of ores.

The ores of the Vizagapatam district are composed mainly of psilomelane with subordinate amounts of pyrolusite, braunite, manganmagnetite, and in one case (Garividi) vredenburgite. They are usually second and third grade—although some first-grade ore has been obtained at Kodur—and can be divided into manganese-ores (above 40 per cent. Mn) and ferruginous manganese-ores (below 40 per cent. Mn). They are characterised by high iron and phosphorus contents, and comparatively low silica (see table 70).

B.—The Gondite Group.

The gondite series.

The gondite series[1] is composed of metamorphosed manganiferous sediments of Dharwar age, and is characterised by the presence of various manganiferous silicates, the most important of which are the

[1] *Mem. Geol. Surv. Ind.*, XXXVII, pp. 306—365.

manganese-garnet, spessartite, and the manganese-pyroxene, rhodonite. The garnet occurs commonly as a rock composed of spessartite and quartz, and this is the rock that has been called *gondite,* after the Gonds, one of the aboriginal races of the Central Provinces. Other common rocks are spessartite-rock, rhodonite-rock, and rhodonite-quartz-rock. The series is developed typically in the districts of Balaghat, Bhandara, Chhindwara, and Nagpur, in the Central Provinces, but has also been found in several other areas, namely :— Narukot State in Bombay, Jhabua in Central India, Gangpur State in Bihar and Orissa, and probably in Banswara State in Rajputana. It exists also in the Seoni district, Central Provinces.[1]

Forming an integral portion of the same masses of rock as the gonditic rocks, there are, at many places, bodies of manganese-ore, often of large size and first-rate quality, some of the manganese-ore deposits of the Central Provinces being the most valuable in India, and second to none found in other parts of the world.

Origin.

The rocks of the gondite series are supposed to have been formed by the metamorphism of a series of sediments deposited during Dharwar times. These sediments were partly mechanical (sands and clays) and partly chemical (manganese oxides). When these sediments were metamorphosed, the sands and clays were converted into quartzites, mica-phyllites and mica-schists ; the purest of the manganese-oxide sediments were compacted into crystalline manganese-ores; whilst mixtures of the mechanical sediments, sand or clay, with the chemical sediment, manganese oxide, were converted into rocks composed of manganese silicates—spessartite and rhodonite—any silica left over after accounting for the formation of these minerals appearing as quartz. [The effects of regional metamorphism have been in some cases complicated by contact effects with resultant hybridism due to later intrusives.[2]] The rocks thus formed constitute the *gondite series.* There is abundance of evidence to prove that the manganese-silicate-rocks of the gondite series have been subjected to extensive oxy-alteration, subsequent to their formation, but probably in Archæan times. As a result of this alteration large bodies of manganese-ore have been formed ; no decisive evidence has yet been obtained indicating the relative proportions of the workable ores that are the result of the direct compression of the purer

[1] R. C. Burton, *Rec. Geol. Surv. Ind.*, XLIV, p. 21, (1914).
[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLV, p. 104, (1915).

portions of the original manganese-oxide sediments [1] and of the ores that have been formed by the subsequent alteration of the rocks of the gondite series.

Nagpur-Balaghat area: mode of occurrence.

The ore-bodies thus formed occur as lenticular masses and bands intercalated in the quartzites, schists, and gneisses; and, as would be expected from the suggested mode of origin, the ore is frequently found to pass, both laterally and along the strike, into the partly altered or quite fresh members of the gondite series, the commonest rock being gondite itself. The ore-bodies are often well-bedded parallel to the strike of the enclosing rocks, and several of them are often disposed along the same line of strike, indicating that they have probably all been produced from the same bed of manganiferous sediment. A good example of such a line of deposits is one in the Nagpur district, stretching from Dumri Kalan in an easterly direction as far as Khandala, a total distance of 12 miles, this line including the valuable deposits of Beldongri, Lohdongri, Kacharwahi, and Waregaon. With the enclosing rocks the ore-bodies have often suffered repeated folding, upon which is often superposed a well-marked pitch.

Dimensions of ore-bodies.

The ore-bodies often attain great dimensions. The Balaghat deposit is $1\frac{3}{4}$ miles long; at Manegaon in the Nagpur district the ore-body is $1\frac{1}{2}$ miles long; whilst the band running through Jamrapani, Thirori, and Ponia, in the Balaghat district, is exposed more or less continuously for nearly 6 miles. In the last Review a thickness of 100 feet (of ore) was ascribed to the Kandri deposit and of 1,500 feet (ore and gonditic rocks) to the Ramdongri deposit. Subsequent work indicates that both these deposits are folded, and there is no evidence that the ore-bodies are anywhere more than 45 to 50 feet thick: greater apparent thicknesses appear to be due to duplication by folding. On the other hand the ore-band is often much thinner, but may have again attained a fictitious thickness due to folding. The depth to which these ore-bodies extend is unknown. It is, however, almost certain that, in many cases, they extend to at least 100 to 400 feet

[1] The fact that some of the gonditic manganese-ores are of great antiquity (at least pre-pegmatite in age) was conclusively proved by the discovery of a detached fragment of ore in pegmatite cutting the Gowari Warhona manganese-ore deposit, Chhindwara district. See L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLI, pp. 1—11, (1911). Similar phenomena have since become well exposed at Kachhi Dhana and Sitapar in the same district.

below the outcrop, *e.g.*, some of the deposits occupying hills in the Central Provinces ; and it is very probable that some of the Central Provinces deposits extend to depths considerably greater than these ; for the evidence obtained indicates that the deposits were formed in depth, so that the position of the deposit bears no genetic relation to that of the surface. An idea of the size of some of these deposits can be obtained from the amounts of ore they have yielded, as shown in the following table :—

TABLE 77.—*Total Production of Manganese-ore from Deposits of Gonditic Type that have yielded 100,000 tons by the end of 1913.*

——	Mine.	District or State in which situated.	Year of commencement of work.	Total production to end of 1913.
1	Balaghat . .	Balaghat . .	1901	725,248 tons.
2	Kandri . .	Nagpur . .	1900	488,814 „
3	Chikhla . .	Bhandara . .	1901	384,452 „
4	Mansar . .	Nagpur . .	1900	331,529 „
5	Lohdongri . .	„ . . .	1900	245,163 „
6	Thirori . .	Balaghat . .	1902	218,040 „
7	Kajlidongri . .	Jhabua . . .	1906	188,755 „
8	Gariajhor . .	Gangpur . .	1908	180,558 „
9	Kachi Dhana . .	Chhindwara . .	1906	140,406 „
10	Kodegaon . .	Nagpur . . .	1903	131,523 „
11	Miragpur . .	Bhandara . .	1905	131,197 „
12	Sukli . . .	„ . . .	1905	123,715 „
13	Gumgaon . .	Nagpur . . .	1901	101,721 „

The total production from deposits of the gonditic type (the Central Provinces, Jhabua, and Gangpur) averaged 529,152 tons annually during the quinquennium.

Composition of ores.

The typical ores of the Nagpur-Balaghat area of the Central Provinces consist of mixtures of braunite and psilomelane of different degrees of coarseness of grain. The most typical ore is a hard fine-grained ore composed of these two minerals. Other minerals found in the Central Provinces ores are hollandite, vredenburgite, sitaparite, and rarely pyrolusite. The unique ore of Sitapar in the Chhindwara district, consisting of hollandite with sitaparite and fermorite, has proved to be a surface form, and at a depth of

60 feet has almost entirely given place to braunitic ore. The ores exported from the Central Provinces are nearly all of first grade, although at times of high prices a small quantity of second-grade ore is exported. The chief characteristics of these ores are the high manganese contents (usually 49 to 54 per cent. as exported), moderately high iron (usually 4 to 8 per cent.), rather high silica (usually about 6 to 9 per cent., and largely due to the braunite in the ore), and fairly low phosphorus (about 0·07 to 0·14). For analyses see table 70, page 158.

Ores in crystalline limestones.

In addition to the deposits found in association with spessartite- and rhodonite-bearing rocks in the Central Provinces, manganese-ores are sometimes found in association with crystalline limestones, usually containing piedmontite, and also regarded as of Dharwar age. Ores of this character are found characteristically in the Nagpur and Chhindwara districts. The manganese-ores occur either as lines of nodules or as fairly definite beds in the limestone, the latter being the rarer mode of occurrence. In most cases it is not found profitable to work these ores ; but where the bed of ore is of greater thickness than usual, as in the Junawani forest, it may pay at times of high prices ; whilst patches of residual nodules accumulated during the dwindling of limestones will pay to work at any time, if not too far removed from transport facilities. The ores found thus are usually composed of braunite and psilomelane or hollandite. These ores, and the associated crystalline limestones and calcareous gneisses, are probably the products of the metamorphism of calcareous sediments with associated manganiferous ores, and are thus analogous in origin to the ores associated with the true gonditic rocks.

The remarks in the foregoing paragraphs apply particularly to the deposits found in the Central Provinces, but also in a general way to the deposits found associated with rocks of the gondite series in other parts of India. A few remarks about these are given below.

Gangpur, Bihar and Orissa.

During 1908 the extension of the gondite series into Bihar and Orissa was proved by the discovery of manganese-ore deposits in Gangpur State associated with rocks containing spessartite and rhodonite. The ores are typical gonditic ores, containing braunite in a matrix of psilomelane. Some 180,000 tons of ore have been won at Gariajhor during the years 1908 to 1913. But the production figures (table

57) suggest the rapid exhaustion of the upper portions of the deposit. In quality the ore is similar to that of the Central Provinces.[1]

The following figures are summarised from analyses supplied by the late Mr. I. Shrager of cargoes shipped during 1909, the manganese and phosphorus figures representing eight analyses on a total of 3,600 tons of ore, and the other constituents four analyses on a total of 1,600 tons of ore :—

—	Limits of analyses.	Mean of analyses.
Manganese	47·64 —54·13	50·53
Iron	5·53 — 6·35	5·85
Silica	2·6 — 8	5·7
Phosphorus	0·018— 0·143	0·089
Moisture	0·78 — 1·16	0·96

Narukot, Bombay.

Rocks of the gondite series with associated manganese-ore have been found in a small hill at Jothvad in Narukot State, Bombay. The occurrence is of no economic importance, but of great scientific interest. The rock surrounding the hill is a porphyritic biotite-granite presumably of Archæan age, and apophyses from this pierce the gonditic rocks of the hill. Isolated pieces of gonditic rocks are included in the granite, and amongst these inclusions are pieces of manganese-ore, proving that a portion at least of the manganese-ore had been formed before the time of intrusion of the granite into the Dharwar rocks of the area.

Panch Mahals.

Manganese-ore deposits are being worked near Sivarajpur in the Panch Mahals. The rocks with which they are associated are Champaners, that is Dharwars ; no rocks of gonditic nature have been found in this area, but it seems, judging from reports, that, although a portion of the ores has certainly been formed by the superficial replacement of quartzites, a portion may have been deposited con-

[1] For a brief account of this deposit see L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLI, pp. 12—18, (1911).

temporaneously with the enclosing Dharwar rocks ; in this case the deposits may be classified with the gonditic deposits. The absence of gonditic rocks would then mean that the rocks—as at the Balaghat deposit in the Central Provinces—had not been subjected to such intense metamorphism as that which produced the gonditic rocks associated with most of the Central Provinces deposits. 229,270 tons of ore have been won from this area in the eight years 1906 to 1913. The composition of the ore can be seen from table 70.

Jhabua, Central India.

The chief deposit in Jhabua State is that situated at Kajlidongri. This is a true gonditic occurrence, and the rocks associated with the manganese-bearing rocks are those known as Aravallis, which are in this part of India the equivalents of the Dharwars. In the six years 1903 to 1908 this deposit has yielded nearly 150,000 tons of manganese-ore, but during the present quinquennium only an additional 43,000 tons have been won. For the quality of the ore see table 70.

C.—The Lateritoid Group.

Lateritoid deposits.

In several parts of India manganese-ore deposits are found on the outcrops of rocks of Dharwar age, associated with the latter in such a manner as to leave little doubt that the ores have been formed by the replacement at the surface of Dharwar schists, phyllites, and quartzites. The masses of ore thus formed do not consist entirely of manganese-ore, but often contain considerable quantities of iron-ore ; and every gradation is to be found from manganese-ores, through ferruginous manganese-ores and manganiferous iron-ores, to iron-ores. The masses of ore thus formed are often more or less cavernous and bear considerable resemblance to ordinary laterite. In fact some geologists would designate such occurrences by this term; but others would object : and, therefore, to obviate this difficulty the term *lateritoid*—meaning *like laterite*—has been introduced to designate this class of deposit. Lateritoid deposits are, then, irregular deposits of iron and manganese-ores, occurring on the outcrops of Dharwar rocks, and resembling in their cavernous and rugged aspect masses of ordinary laterite. When the rock replaced is a schist or phyllite, it is usually found altered to lithomarge below the capping of ores. The mineral composition of the ores thus formed is usually fairly simple. The manganese-ores are pyrolusite,

psilomelane, wad, and more rarely pseudo-manganite, and manganite; whilst the iron ores are limonite and earthy hematite. The harder crystalline minerals—braunite, vredenburgite, sitaparite, magnetite, and specular hematite—are found rarely or never in the lateritoid ores. Hollandite may sometimes occur. The chemical characteristics of the manganese-ores are high iron, low silica, and often very low posphorus. The manganese is usually correspondingly low, so that the ores won consist mainly of second-grade manganese-ores and third-grade ferruginous manganese-ores. Such deposits will be worked to the greatest advantage when a market can be found for the iron-ores and manganiferous iron-ores, as well as for the manganese-ores.

Singhbhum and Jubbulpore.

The areas where ores of this nature have been found are given on page 169. Singhbhum and Jubbulpore have yielded small quantities of merchantable ore, but the most important of the lateritoid areas are Mysore and Sandur. A large number of deposits, many of them of large size, have been located in the Sandur Hills, mostly perched up on the edge of the hills at an average elevation of about 1,000 feet above the plains. When transport difficulties have been surmounted, these deposits may be expected to yield large quantities of second-grade and third-grade ores, with possibly a certain proportion of first-grade ore from the Kamataru portion of the State. The deposits are being worked by the General Sandur Mining Company, Ltd. During the years 1905 to 1908 some 50,000 tons of ore were won from these deposits, mainly from the Ramandrug and Kannevihalli areas, and during the succeeding five years an additional 334,000 tons. For analyses see table 70, page 148. The manganese-ore deposits of Mysore are numerous, but very few of them can compare in size with those of the Sandur Hills, although they have been formed in the same way. The chief exception is the Kumsi deposit in the Shimoga district, from which some 160,000 tons of ore were won in the three years 1906 to 1908. The industry started in Mysore in 1906 and assumed a condition of great activity during 1906 and 1907. About 230,000 tons of ore were won in the three years 1906 to 1908, whilst in the present quinquennium only 141,401 tons have been won, the output having declined by 1913 to only 10,501 tons. The chief companies operating in this State were the Workington

Iron Company, Ltd., operating in the Shimoga district; the Peninsula Minerals Company of Mysore, Ltd., operating in the Chitaldrug and Tumkur districts; and the Shimoga Manganese Company, Ltd., operating in the Kadur and Shimoga districts. But the last-named company appears to have ceased operations; and the general decline of the industry during the quinquennium is doubtless largely due to the superficial nature of the deposits leading to early exhaustion of the best class of ores, whilst high railway and sea freights prevent the exploitation of the lower-grade ores.

The Laterite Group.

Goa and Belgaum.

Manganese-ores are sometimes found in true laterite; but such ores are rarely of much economic value. The ores of Goa (Portuguese India) occur in part in this way (in low-level laterite), as also those of Belgaum (in high-level laterite). They are not economically of great importance, owing to the irregular manner in which they occur, and their extremely variable composition. Picked ores, however, are similar in composition to the picked lateritoid ores. 16,243 tons of ore won in Goa were exported from Mormugao during the period 1909-13. These exports are, of course, excluded from table 60.

The production of manganese-ore in Goa during the present period, as supplied by the British Consul at Mormugao, was as follows:—

1909	4,371	tons
1910	6,435	„
1911	3,581	„
1912	300	„
1913	1,556	„

Mica.

Production.

The total and provincial production of mica in India during the five years 1909 to 1913 is shown in table 78. From this it will be seen that the production has risen from 32,903 cwts. in 1909 to 45,761 cwts. in 1913. At the same time the average annual production for the period was 35,817 cwts. which is lower by 5,400 cwts. than the

average figure for the previous quinquennial period. This is due to the fact that during the last quinquennial period owing to the invention of micanite much material, formerly worthless, suddenly acquired commercial value; as the old waste-heaps furnished large supplies there was a sudden increase of production from under 26,000 cwts. in 1905 to over 52,000 cwts. in 1906. Production, however, soon outstripped export, stocks accumulated, and in 1910 the production fell to its former level. Since then, however, it has again increased.

From table 78 it will also be seen that more than half the Indian production (over 71 per cent.) is contributed by Bihar and Orissa—the mica mines lying in the districts of Hazaribagh, Gaya, and Monghyr. Madras contributes a little less than 25 per cent., chiefly from the Nellore district. Ajmer and Marwara in Rajputana contribute the remaining 4 per cent., their share of the industry having fallen considerably since the end of the last quinquennial period and being only 1,284 cwts. on the average during the period under review as against 4,664 cwts. in 1904-08. Mysore produced a small quantity during each of the years 1911, 1912 and 1913.

TABLE 78.—*Provincial Production of Mica for the years 1909 to 1913.*

PROVINCE.	1909.	1910.	1911.	1912.	1913.	*Average.*
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	*Cwts.*
Bihar and Orissa .	22,084	18,356	25,225	29,653	32,579	*25,579*
Madras . .	8,948	3,586	7,462	13,484	10,861	*8,868*
Rajputana . .	1,871	757	1,191	650	1,953	*1,284*
Mysore . .	..	..	18	45	29	*18*
TOTAL .	**32,903**	**22,699**	**33,896**	**43,832**	**45,422**	*35,749*

Exports.

Table 79 shows the quantity and value of the mica exported during the years 1908-09 to 1913-14, the average quantity being 45,381 cwts., or 2,269 tons, of an average value of £4·85 per cwt. The average quantity during the period of the previous Review was 32,605 cwts., or 1,630 tons, worth on an average £4·05 per cwt.

Internal consumption.

Comparison of these figures with those for production gives the rather startling result that there has been an excess of exports over production. The total excess for the five years 1909-10 to 1913-14 amounts to 66,805 cwts., from which it would appear that either the returns of production were very incomplete or that there were large stocks in reserve. It is probable that both these factors were operative. There is no doubt that all the mica won does not figure in the returns and that understatement is employed as a means of evading royalty. Theft is also prevalent in the mica-mining centres and tends to reduce the apparent production, since the stolen material does not figure in any returns. At the same time these two causes are not adequate to account for the great excess of exports over output, an excess which is greater than would appear at first sight, since an appreciable quantity must also be set aside for internal consumption. In the previous Review the latter amount was estimated at 400 tons per annum ; so far as can now be ascertained this estimate is probably a good deal too high since, if correct, the whole output of the years 1904-08 would have been absorbed by the end of that period and it would be necessary to ascribe to faulty returns the whole discrepancy between the exports for the period 1909-13 and the output for the same period. On the other hand, the output during each of the three years 1906, 1907, and 1908 was phenomenally large, being over 52,000 cwts., while the exports, except in 1906-07, fell short of the annual production by about 20,000 cwts. in each year. There was thus, at the beginning of the period now under review, a considerable reserve of mica in the country, and the excess of exports over production during the succeeding years can thus be accounted for. During the period 1904-08, the excess of production over exports was altogether 38,226 cwts. for the whole period, whereas during 1909-13, the excess of exports was 66,805 cwts. For the period of ten years, therefore, the balance in favour of export is a little over 28,579 cwts.; this, together with the internal consumption, will represent the amount of mica that has not figured in the returns and has thus escaped paying royalty. Putting the internal consumption as low as 2,000 cwts. per annum, the total amount of mica that has evaded royalty each year for the last ten years will be, on an average, nearly 5,000 cwts. This represents a loss of royalty amounting to about £1,200 per annum.

TABLE 79.—*Exports of Indian Mica during the years 1908-09 to 1913-14.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	£
1908-09	26,392	*126,834*	4·80
1909-10	33,963	*154,978*	4·56
1910-11	42,593	*188,983*	4·43
1911-12	48,871	*207,778*	4·25
1912-13	66,574	*341,349*	5·12
1913-14	53,891	*302,564*	5·61
Average .	*45,381*	*220,414*	*4·85*

TABLE 80.—*Exports of Mica for the years 1908-09 to 1913-14.*

YEAR.	BIHAR AND ORISSA.			BOMBAY.			MADRAS.		
	Weight.	Value.	**Value per cwt.**	Weight.	Value.	**Value per cwt.**	Weight.	Value.	**Value per cwt.**
	Cwts.	£	£	Cwts.	£	£	Cwts.	£	£
1908-09	17,857	90,311	**5·06**	845	3,672	**4·34**	7,690	32,851	**4·27**
1909-10	30,452	137,383	**4·51**	357	2,019	**5·65**	3,151 (*a*)	15,564 (*a*)	**4·94** (*a*)
1910-11	37,533	164,428	**4·38**	309	1,868	**6·04**	4,751	22,687	**4·77**
1911-12	40,228	166,186	**4·13**	336	1,321	**3·93**	8,307	40,271	**4·85**
1912-13	56,504	292,645	**5·18**	816	5,524	**6·77**	9,254	43,180	**4·67**
1913-14	41,313	236,765	**5·73**	1,707	9,397	**5·50**	10,871	56,402	**5·19**
Average	*37,314*	*181,286*	**4·85**	*728*	*3,967*	**5·45**	*7,337*	*35,159*	**4·79**

(*a*) Exclusive of 3 cwts. valued at £12, exported from Burma during 1909-10.

Distribution of mica exported.

Table 81 shows the average distribution of exported mica during the period under review. The United Kingdom as usual took the largest share, amounting to 59·0 per cent. of the average total value, but much of the mica sent to the United Kingdom is sold there for transmission to the Continent and America. The mica sent direct to America brought a higher price than that sent to other countries,

since only the better qualities can stand the heavy import duty imposed.

TABLE 81.—*Average distribution of Indian Mica exported during the years 1908-09 to 1913-14.*

Exported to	Average Quantity.		Average Value.		Value per cwt.
	Cwts.	*Per cent. of total.*	£	*Per cent. of total.*	£
United Kingdom	25,133	*55·4*	130,102	*59·01*	5·17
United States	7,689	*16·9*	40,474	*18·36*	5·26
Germany	7,300	*16·1*	27,724	*12·58*	3·80
Holland	3,576	*7·9*	13,828	*6·27*	3·86
Belgium	319	*·7*	1,503	*·68*	4·71
France	705	*1·6*	3,576	*1·62*	5·07
Other countries	659	*1·4*	3,207	*1·45*	4·86
Average Total	**45,381**	*100·0*	**220,414**	*100 0*	4·85

World's production.

Practically the whole of the world's output of mica is derived from India, Canada, and the United States. In table 82 are shown the values of the mica raised during the past twenty years in the three leading countries. From this it will be seen that in the quinquennium 1894 to 1898, India contributed 65·1 per cent. of the total; in the next quinquennium (1899 to 1903), owing to the increased output from Canada, the Indian contribution decreased to 60·1 per cent.; whilst during the third quinquennium (1904 to 1908), the Indian mica industry expanded enormously, but the proportion increased only to 61·8 per cent. owing to a great increase in the American production and an abnormally large production by Canada (£116,209) in 1906. In the period now under review, India's share has again increased to 65·1 per cent., Canada's has decreased by 4½ per cent., and America's by about 2 per cent. The figures given in table 82 are summarized in table 83, from which it will be seen that during the twenty years India has contributed roughly three-fifths of the total and Canada and the United States roughly one-fifth each.

TABLE 82.—*Value of Mica raised in the three Principal Producing Countries during the twenty years 1894 to 1913.*

YEAR.	Canada.	India. (a)	United States of America.	Total.	*India's per cent. of total.*
	£	£	£	£	
1894	9,116	42,516	9,415	**61,047**	*69·64*
1895	13,000	71,481	7,671	**92,152**	*77·57*
1896	12,000	76,891	9,223	**98,114**	*78·37*
1897	15,200	71.238	22,424	**108,862**	*65·44*
1898	23,675	53,890	26,414	**103,979**	*51·83*
TOTAL	**72,991**	**316,016**	**75,147**	**464,154**	..
Average	*14,598*	*63,203*	*15,030*	*92,831*	*68·08*
1899	32,600	73,372	25,576	**131,548**	*55·78*
1900	33,200	109,554	25,079	**167,833**	*65·28*
1901	32,000	70,034	23,716	**125,750**	*55·69*
1902	27,181	87,594	19,385	**134,160**	*65·29*
1903	35,571	86,297	28,626	**150,494**	*57·34*
TOTAL	**160,552**	**426,851**	**122,382**	**709,785**	..
Average	*32,110*	*85,370*	*24,477*	*141,957*	*60·14*
1904	30,584	97,932	24,063	**152,579**	*64·18*
1905	33,634	159,627	40,231	**233,492**	*68·37*
1906	116,209	254,999	54,998	**426,206**	*59·83*
1907	66,604	228,161	78,422	**373,187**	*61·11*
1908	38,320	126,834	53,585	**218,739**	*57·97*
TOTAL	**285,351**	**867,553**	**251,299**	**1,404,203**	..
Average	*57,070*	*173,511*	*50,260*	*280,841*	*61·78*
1909	30,345	154,978	57,603	**242,926**	*63·79*
1910	39,093	188,983	69,219	**297,295**	*63·56*
1911	26,422	207,778	73,060	**307,260**	*67·62*
1912	29,564	341,349	68,151	**439,064**	*77·74*
1913	34,931	302,564	89,540	**427,035**	*70·85*
TOTAL	**160,355**	**1,195,652**	**357,573**	**1,713,580**	..
Average	*32,071*	*239,130*	*71,515*	*342,716*	*69·77*

(a) Export values for official years.

TABLE 83.—*World's Production of Mica (Summary of Table 82).*

PERIOD.	Canada.	India.	United States.	Total.
	£	£	£	£
1894-1898	72,991	316,016	75,147	**464,154**
1899-1903	160,552	426,851	122,382	**709,785**
1904-1908	285,351	867,553	251,299	**1,404,203**
1909-1913	160,355	1,195,652	357,573	**1,713,580**
TOTAL .	**679,249**	**2,806,072**	**806,401**	**4,291,722**
Per cent. of total .	*15·83*	*65·38*	*18·79*	*100·00*

Increased use of mica.

It will be noticed that, commencing with 1905, there has been a great increase in the world's annual production of mica. This is due largely to the invention of *micanite,* in which small and inexpensive sheets of mica are cemented together with shellac under pressure, with the production of large sheets costing much less than the natural sheets of equal size. The decreased cost of this material led to the increased application of mica in the arts, especially for electrical insulation. Furthermore, scrap mica, formerly thrown away, is now ground up and used for boiler and pipe lagging, as a lubricant, and for wall papers and paints.

Mining methods.

An important contribution to our knowledge of the mica deposits in the Kodarma area has been made by Mr. A. A. C. Dickson,[1] who has made a practical modification of the system of mining suggested in the Memoir published by the Geological Survey in 1902.[2] Mr. Dickson does not consider that overhand stoping, on account of the dangers incurred in the employment of a large number of untrained miners, can be universally followed in working out the mica-bearing pegmatite sheets and masses. He advocates and practises a system which he describes as 'transverse stoping with filling.' The pegmatite is followed to a depth of about 100 feet or more, and then, the dip being determined, an exploratory drift is run along the hanging wall of the sheet to fix its strike, which enables the construction of a main haulage way for the removal of the mica and associated waste minerals during the process of stoping out the material by a series of transverse cuts. Mr. Dickson has confirmed previous conclusions regarding the unnecessary cost of labour in carrying out the old system whereby in a mine only 75 feet deep over 200 workers are often required to deal with the material raised by ten miners at work below, and he has consequently given some practical suggestions for the introduction of simple machinery to deal with the water and dispose of waste materials. He agrees, therefore, that in the Kodarma area the day of the petty miner has passed, and the organisation of systematic mining with the help of machinery requires an expenditure of capital best obtainable by limited liability companies.

The mica mines of Madras (Nellore) have recently been described in some detail by Mr. A. Krishnaiya.[3]

Labour statistics.

Most of the mica mines are under the control of the Indian Mines Act of 1901, so that the labour statistics for the period under review, given in table 84, afford a fair index of the activity of the industry. The average number of persons employed during the quinquennium was 14,939. The risks attending mica mining seem to be much less than those of coal-mining in India.

[1] *Trans. Min. Geol. Inst. of India*, III, p. 57, (1908).
[2] T. H. Holland, 'The Mica Deposits of India,' *Mem. Geol. Surv. Ind.*, XXXIV, part 2, p. 78.
[3] *Trans. Min. Geol. Inst. of India*, Vol. V, p. 181, (1910).

TABLE 84.—*Labour Statistics of Mica Mines for the years 1909 to 1913.*

PROVINCE.	1909.	1910.	1911.	1912.	1913.	*Average.*
NUMBER OF PERSONS EMPLOYED—						
Bihar and Orissa . .	6,878	10,581	11,795	11,973	12,314	*10,708*
Madras	2,904	2,720	3,531	4,613	6,002	*3,954*
Rajputana . . .	83	200	248	435	418	*277*
TOTAL .	**9,865**	**13,501**	**15,574**	**17,021**	**18,734**	**14,939**
NUMBER OF DEATHS FROM ACCIDENTS AT MICA MINES—						
Bihar and Orissa . .	7	3	9	2	.	*4·2*
Madras	..	2	1	..	..	·6
Rajputana . . .	.	..	..	..	..	..
TOTAL .	**7**	**5**	**10**	**2**	..	**4·8**
DEATH-RATE PER 1,000 PERSONS EMPLOYED AT MICA MINES—						
Bihar and Orissa . .	1·01	0·28	0·76	0·16	..	*0·39*
Madras	..	0·73	0·28	..	..	*0·15*
Rajputana . . .	..	..	..	..	..	..
Average .	*0·70*	*0·37*	*0·64*	*0·11*	*0·19*	*0·32*

NOTE.—These figures relate only to mines under the Indian Mines Act.

Monazite.

Monazite, which is a phosphate of the rare earths cerium and lanthanum, owes its economic value to the fact that it contains also a certain percentage of thoria and constitutes the raw material for the production of thorium nitrate, which is used in the manufacture of gas mantles.

Until quite recently the world's supply of monazite was derived from sands in Brazil, but the discovery of similar sands on the coasts of Travancore and Cochin[1] has enabled India to enter the market and to create an industry worth over £40,000 in 1913.

The monazite, which is derived from the gneisses of the Travancore hills, is one of the constituents of the sands along the sea-shore, and in certain places selective action by the waves on these sands has led to the local concentration of large quantities of monazite; the sand is again further concentrated by artificial means. In 1911 work was begun by the London Cosmopolitan Mining Co., and, during the years 1911-1913, 3,202 tons of concentrates valued at £107,475 were extracted. The whole of the output is said to have been sent to Hamburg.

Monazite occurs also to the east of Cape Comorin, in the Tinnevelly district, and again near Waltair in Vizagapatam.

Petroleum.

Total production.

During the previous period reviewed the production of petroleum increased from 118½ million gallons in 1904 to 176½ millions in 1903. During the past quinquennium the production has again increased, reaching the record output of 277½ million gallons in 1913. The increased production, as shown in table 85, has been due almost entirely to greater activity in Burma, and especially to the Yenangyaung field, where the wells have reached depths of 2,000 feet and more.

Position of India amongst oil-producing countries.

Nevertheless, India still occupies a comparatively low place among the oil-producing countries, and in 1912 turned out only 2·09 per cent. of the world's total supply. It will be seen from table 86 that although her contribution has increased slightly, India has now fallen to the seventh place among the chief oil-producing

[1] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XLIV, p. 186, (1914).

countries, having been outstripped by Mexico. America still contributes more than half the world's supply.

TABLE 85.—*Production of Petroleum during the years 1909 to 1913.*

YEAR.	QUANTITY.		Value.
	Gallons.	*Metric tons.* (a)	
			£
1909	233,678,087	*938,466*	910,172
1910	214,829,647	*862,770*	835,927
1911	225,792,094	*906,796*	884,398
1912	249,083,518	*1,000,335*	975,278
1913	277,555,225	*1,114,680*	1,034,586
Average	*240,187,714*	*964,609*	*928,072*

(a) The metric ton is assumed to be equivalent to 249 Imperial gallons of crude petroleum, most of which has an average specific gravity of about 0·885.

TABLE 86.—*World's Production of Petroleum in 1908 and 1912.*

COUNTRIES.	1908.		1912.	
	Metric Tons.	*Per cent. of total.*	Metric Tons.	*Per cent. of total.*
United States	23,942,997	*62·92*	29,615,096	*62·64*
Russia	8,291,526	*21·80*	9,317,700	*19·71*
Mexico	464,188	*1·22*	2,207,762	*4·67*
Roumania	1,147,727	*3·02*	1,806,942	*3·82*
Sumatra, Java, Borneo	1,143,243	*3·00*	1,478,132	*3·13*
Galicia	1,754,022	*4·60*	1,187,007	*2·51*
India	672,938	*1·77*	989,801	*2·09*
Peru	134,828	*·35*	233,486	*·49*
Japan	276,124	*·73*	222,854	*·47*
Germany	141,900	*·37*	140,000	*·30*
Canada	70,400	*·19*	32,612	*·07*
Italy	8,344	*·03*	12,000	*·03*
Other countries	4,000		33,333	*·07*
TOTAL	**38,052,237**	*100·00*	**47,276,725**	*100·00*

Imports of kerosene.

Foreign mineral oil has been to a certain extent displaced by the domestic products, but the consumption has greatly increased in India and there is thus still a large market in India and Burma for foreign oil, which has to pay an import duty of 1½ annas per gallon. The average annual imports of foreign mineral oils during the period 1903-04 to 1907-08 amounted to about 73½ million gallons, valued at nearly 2 millions sterling, while for the five financial years 1908-09 to 1912-13 the average annual import rose to a little over 91 million gallons, valued at 2½ millions sterling. The largest import occurred in 1911-12, when nearly 107½ million gallons of foreign oil came into India, while the lowest figure, 77½ million gallons, was reached in 1909-10. The chief feature of the period under review is the complete domination, by America, of the imports. In the preceding quinquennial period America's share of the imports rose from 13·5 per cent. to 56·2 per cent., while Russia's fell from 71 to 6, the average for the two countries during the whole period, 1903-1908, being 32·5 per cent. for America and 31·8 for Russia. This tendency persisted into and throughout the period now under review, with the result that America's average contribution during the five years was 53·2 per cent. and Russia's only 7·2. At the same time Borneo has taken the next place to America, with an average contribution of 18 per cent. of the imports. The remaining imports, ascribed to other countries, amount to 21·6 per cent. of the total; these countries include Germany, Roumania, Sumatra and Persia; of these Roumania and Sumatra were formerly the most important, but they will probably be rapidly outstripped by Persia during the next quinquennial period. The operations of the Anglo-Persian Oil Co. had not resulted in any very large output of refined products during the period covered by this review, but the recent action of the British Government in taking up a large number of shares in the company and thereby advancing £2,000,000 sterling, will lead to very extensive development in the near future, and will result in Persia taking an important place among the oil-producing countries of the world.

Value of imports.

The values of the imported mineral oil during the period under review are shown in table 88; the average annual value was £2,451,987 as compared with an average of £1,944,175 for the previous period. The average value per gallon for Russian (6·45 to 6·21 pence) and

TABLE 87.—*Origin of Foreign Mineral Oil imported into India during the years 1908-09 to 1912-13.*

COUNTRIES.	1908-09.		1909-10.		1910-11.		1911-12.		1912-13.		*Average.*	
	Gallons.	*Per cent. of total.*	Gallons.	*Per cent of total.*	Gallons.	*Per cent of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*
Russia	8,187,917	*8·5*	3,585,189	*4·6*	5,841,988	*7·4*	2,922,582	*2·7*	2,469,405	*13·1*	4,601,416	*7·2*
Borneo	16,309,546	*16·8*	12,157,540	*15·7*	10,848,005	*13·6*	21,950,997	*20·4*	20,841,441	*21·9*	16,421,506	*18·0*
United States	39,974,106	*41·3*	48,997,215	*63·2*	43,010,715	*54·0*	69,274,706	*64·5*	41,664,150	*43·7*	48,584,178	*53·2*
Other countries	32,374,975	*33·4*	12,739,018	*16·5*	19,943,740	*25·0*	13,268,244	*12·4*	20,287,010	*21·3*	19,722,598	*21·6*
TOTAL	**96,846,544**	*100·0*	**77,478,962**	*100·0*	**79,644,448**	*100·0*	**107,416,529**	*100·0*	**85,262,006**	*100·0*	**89,329,698**	*100·0*
	£		£		£		£		£		£	
Value	2,602,765		2,088,240		2,248,707		2,818,127		2,502,097		2,451,987	

American (7·41 to 7·01 pence) oils has fallen slightly, and that for other oil imported has risen slightly (5·24 to 6·93 pence).

The annual exports of oil and of paraffin wax have increased six-fold and four-fold respectively (see table 89).

Exports.

TABLE 88.—*Annual Value of Mineral Oil imported during the years 1908-09 to 1912-13.*

Countries.	1908-09.	1909-10.	1910-11.	1911-12.	1912-13.	Average.		*Average value per gallon.*
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	£	*Pence.*
Borneo .	40,62,030	34,11,510	27,90,375	61,26,585	55,88,280	43,95,756	293,050	*4·28*
Russia .	32,71,905	14,57,070	23,92,770	8,91,075	48,05,115	25,63,587	170,906	*6·21*
United States	1,96,76,925	2,12,72,085	1,86,19,170	2,91,96,450	1,76,41,425	2,12,81,211	1,418,747	*7·01*
Other countries.	1,20,30,615	51,82,935	99,28,290	60,57,795	94,96,635	85,39,254	569,284	*6·93*
TOTAL .	**3,90,41,475**	**3,13,23,600**	**3,37,30,605**	**4,22,71,905**	**3,75,31,455**	**3,67,79,808**	**2,451,987**	*6·44*

TABLE 89.—*Exports of Mineral Oil and Paraffin Wax during the years 1909 to 1913.*

YEAR.	Mineral oil.	Paraffin wax.
	Gallons.	Cwts.
1909	2,205,649	144,597
1910	2,828,857	230,718
1911	10,460,778	247,679
1912	18,891,404	260,244
1913	25,905,156	272,226
Average .	*12,070,369*	*231,093*

Occurrence of Indian petroleum.

The petroleum resources of India are confined to the two systems of folded rocks at either end of the Himalayan and are :—

(1) The Iranian system on the west, including the Punjab and Baluchistan and continued beyond British limits to Persia, where the oil-fields have attracted interest for many years.

(2) The Arakan system on the east, including Assam and Burma, with their southern geotectonic extension to the highly productive oil-fields of Sumatra, Java, and Borneo.

In both areas the oil is associated with Tertiary strata, and has had, probably, similar conditions of origin in both cases, but the structural features of these areas are not equally suitable for the retention of oil in natural reservoirs. In Burma, however, the conditions have been locally ideal; the well-known Yenangyaung field lies in a N.N.W.—S.S.E. flat anticline, the axis of which by variation in pitch has produced a flat dome in the Kodaung tract. The rocks in this dome include several porous sands at various depths, each covered by an impervious clay-bed, which has helped to retain the oil until the impervious layers are pierced by artificial wells. In the Baluchistan area the rock-folds have been truncated by agents of denudation or have been dislocated by earth-movements and much of the original stores of oil have disappeared. Oil-springs are common enough but they are mere 'shows' not connected with reservoirs that can be tapped by artificial means.

The provincial production of petroleum in India is shown in table 90.

Punjab and Baluchistan.

In the Punjab, oil-springs have been known for many years to exist in the Rawalpindi district and further to the south-west, but the total output of the Punjab (shown in table 90) is very small, ranging during the quinquennium between 400 and 1,700 gallons a year. For an account of the occurrence of oil in Baluchistan, reference should be made to the Quinquennial Review for the years 1898-1903, *Records*, Vol. XXXII, page 74.

TABLE 90.—*Provincial Production of Petroleum during the years 1909 to 1913.*

PROVINCE.	1909.	1910.	1911.	1912.	1913.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Burma . .	230,396,617	211,507,903	222,225,531	245,335,209	272,865,397
Assam (Digboi) .	3,280,750	3,320,680	3,565,163	3,747,359	4,688,628
Punjab . .	720	1,064	1,400	950	1,200
TOTAL, Gallons.	**233,678,087**	**214,829,647**	**225,792,094**	**249,083,518**	**277,555,225**
Total, Metric Tons (a)	*938,466*	*862,770*	*906,796*	*1,000,335*	*1,114,680*

(*a*) The metric ton is assumed to be equivalent to 249 gallons of crude petroleum.

Assam.

Oil-springs are known in various parts of Assam, the most prominent being those at the southern foot of the Khasi and Jaintia hills, and those appearing in the coal-bearing series in North-East Assam, especially in the Lakhimpur district.[1] The only marketable oil obtained comes from the Lakhimpur district, where systematic drilling has been conducted at Digboi during the past fifteen years by the Assam Oil Company, Ltd. The output of the field, however, is very small, the highest production in any year during the period under review having been only a little over 4½ million gallons (see table 90).

The principal products marketed are petrol, jute-batching oil, lubricating oils, paraffin wax and a comparatively low grade of kerosene suitable for bazar consumption. The paraffin wax, sold as such or in the form of candles, appears to be of excellent quality with a melting point of 135° F. and over. Table 91 shows the amounts of the various products turned out during the past five years.

[1] See E. H. Pascoe: The Petroleum Occurrences of Assam, *Mem. Geol. Surv. Ind.*, Vol. XL, part 2, (1914).

TABLE 91.—*Output of the Digboi Oil Refineries in the years 1909 to 1913.*

——	1909.	1910.	1911.	1912.	1913.
Kerosene (*a*) . . .	1,580,191	1,550,692	2,142,349	1,714,070	2,291,531
Batching and lubricating oil (*a*)	426,797	330,850	318,415	345,679	331,450
Petrol (*a*)	36,588	56,736	80,534	120,930	179,776
Wax (and candles) (*b*) .	1,762,946	1,866,351	1,904,544	1,708,221	2,112,074
Sundry oils, including fuel oil. (*a*)	137,105	152,230	278,218	191,885	248,078

(*a*) Imperial gallons.
(*b*) Lbs.

The average number of persons employed daily on the Digboi field during the period under review was 455.

Burma.

The most productive oil-fields of Burma are those on the eastern side of the Arakan Yoma in the Irrawaddy valley forming a belt stretching from the Magwe district, in which the well-known field of Yenangyaung occurs, through Myingyan, in which Singu occurs across the Irrawaddy into Pakokku, where Yenangyat is situated[1] The production of the Burmese oil-fields for the years 1909 to 1913 is shown in table 92. Yenangyaung, the oldest and best known of the fields, still holds an easy lead as a producer. Of the total $1\frac{1}{2}$ square miles of petroliferous territory, all that outside the two native 'reserves' of Twingon and Beme, is held under lease by the Burma Oil Company, the pioneers of this field. It is within the two small reserved tracts covering jointly some 450 acres, and especially

Yenangyaung.

[1] See E. H. Pascoe: The Oil-fields of Burma, *Mem. Geol. Surv. Ind.*, Vol. XL, part 1, (1912).

within the Twingon Reserve, that competition has been so keen as to threaten injury to the oil-sands by water liberated from water-sands, and danger of fire in the midst of a congested forest of greasy wooden derricks covering highly productive flowing wells emitting immense quantities of inflammable gas. The appointment of a Warden, who is assisted by an Advisory Board composed of representatives of the companies engaged in exploiting the field, has now resulted in systematic measures for the protection of the sands and will undoubtedly do much to prolong the life of the field. When the last review was written, it was feared that excessive exploitation was leading to premature exhaustion ; but although the yield from the upper sands is now small, lower horizons have been tapped by the deep wells, which have now reached to 2,000 feet and even lower, and the output of the field continues steadily to increase. It still remains to ascertain the total depth to which the petroliferous horizons extend at Yenangyaung.

TABLE 92.—*Production of the Burma Oil-fields during the years 1909 to 1913.*

OIL-FIELD AND DISTRICT.	1909.	1910.	1911.	1912.	1913.	Average.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	*Gallons.*
Akyab . .	24,758	22,258	19,630	15,626	14,023	*19,259*
Kyaukphyu .	39,064	33,544	36,970	41,304	29,254	*36,027*
Yenangyaung (Magwe).	187,043,800	174,967,298	166,494,319	179,802,842	200,555,668	*181,772,785*
Singu (Myingyan)	37,169,061	31,524,175	50,564,765	56,645,200	63,538,710	*47,888,382*
Yenangyat (Pakôkku).	6,119,934	4,942,308	4,476,074	4,880,422	5,499,191	*5,183,586*
Minbu . .	..	18,320	632,458	3,896,365	3,198,311	*1,936,363* (*a*)
Thayetmyo .	..	..	1,315	53,450	30,240	*28,335* (*b*)
TOTAL, Gallons .	**230,396,617**	**211,507,903**	**222,225,531**	**245,335,209**	**272,865,397**	*236,466,131*
Total, Metric Tons	*925,288*	*849,429*	*892,472*	*985,282*	*1,095,845*	*949,663*

(*a*) Four years only.
(*b*) Three years only.

Yenangyat. The output of the Yenangyat field, which was never a very rich one, has declined seriously; its average annual output during the period under review being only a little over 5 million gallons, or considerably less than half the annual average for the preceding period.

Singu. Although inferior to Yenangyaung, Singu is a promising field, and has up to the present been treated more or less as a reserve. It is now being steadily and scientifically developed by the Burma Oil Company.

Minbu. In the year 1910, the Minbu field began to produce for the first time and in 1912 the output was nearly 4 million gallons. The results of exploitation of the field have, however, hitherto been disappointing.

Chindwin. Oil is said also to have been struck by the Indo-Burma Petroleum Company at Indaw in the Chindwin, but no details are available as yet as to the capacity of the oil-sands.

Arakan coast. Besides the Upper Burma oil-fields the islands off the Arakan coast, noted for their mud volcanoes, have also been known for many years to contain oil deposits of uncertain value. The chief operations have been carried on in the Eastern Barongo Island near Akyab and on Ramri Islands in the Kyaukphyu district. Flooding and denudation in these regions have been too severe to warrant the expectation of oil in much quantity. The output from the Kyaukphyu wells has steadily declined and the average for the past five years is 23,945 gallons less than the average for the five years 1904 to 1908. In the case of Akyab, the decline in this average is 20,842 gallons.

Ruby, Sapphire, and Spinel.

Production. During the period covered by this review, the whole of the output of these stones in the Indian Empire was derived from Upper Burma. During the years 1906 to 1908 the sapphire deposits of Kashmir were again worked, with results at first fairly satisfactory but so poor in 1908 as to offer no incentive for further work. Table 93 shows the annual output figures for Burma during the period under review, the average annual value being £63,272.

TABLE 93.—*Production of Ruby, Sapphire and Spinel in Burma during the period 1909 to 1913.*

Year.	Quantity.	*Value.*
	Carats.	£
1909	265,010	*64,826*
1910	262,019	*58,849*
1911	288,213	*67,594*
1912	323,245	*69,547*
1913	278,706	*55,542*
Average .	*283,439*	*63,272*

Burma.

The prosperous condition noticed in the previous reviews of the ruby mining industry as conducted by the Burma Ruby Mines, Ltd., in the Mogok area, continued until towards the end of 1907, when the demand for rubies suddenly fell away and prices declined, owing to the world-wide commercial depression that then set in. The slump has continued in subsequent years and the value of the production, of which the annual average was over £84,000 during the period 1904-08, fell to £63,272 in the period under review. The effects of the commercial depression have probably been accentuated by the successful manufacture on a commercial scale of synthetic stones.

The Burma Ruby Mines, Ltd., was granted a new lease for 28 years with effect from the 30th April 1904, for the collection of precious stones in the townships of Mogok, Kyatpyin and Katha in the Ruby Mines district. The Company was required by the lease to pay an annual rent of Rs. 2,00,000 (£13,333), *plus* 30 per cent. of the net profits made each year, this being a continuance of the arrangement previously in force. In consequence of the slump, however, the Company was unable to pay dividends for the years 1908-10, but matters improved slightly during 1911 and a dividend at the rate of $4\frac{1}{8}$ per cent. was paid for the year ending February 29th, 1912, and a similar dividend for the year ending February 28th, 1913. The year 1913 was a bad one and resulted

in a deficit of over £9,000 for the twelve months ending February 28th, 1914. Owing to this succession of poor years, the Company was compelled to approach the Burma Government with a view to the remission of arrears of rent and other charges. These amounted in 1909 to nearly £24,000 ; the Government agreed to the postponement of payment of this sum and arranged that the Company should make over the royalties collected from the local native ruby-miners less a fee of 10 per cent. on account of charges for collecting. In 1911, the Company proceeded to develop new ground in the neighbouring valleys of Kathé and Bernardmyo and on the understanding that £20,000 would be spent on such development, the Government agreed, with the sanction of the Secretary of State, to remit the Company's debts on account of arrears until such time as the profit should exceed 10 per cent. on the present paid-up capital. At the end of 1913, the proceeds of local sales fell off to such an extent that further concessions by the Government were found necessary early in 1914.

Labour.

The following are the labour statistics for the ruby mines under the Mines Act :—

YEAR.	Average number of persons employed daily.
1909	1,385
1910	1,463
1911	1,505
1912	1,707
1913	1,815

The number of deaths during the period was 4, giving an average death-rate of 0·54 per 1,000. In addition large numbers of persons are engaged in working on their own account under licenses issued by the Burma Ruby Mines, Ltd.

Rubies are known to occur at Naniazeik in the Myitkyina district near the jadeite tract[1]; but no output has been reported for the period under review. Ruby-bearing ground was also discovered during the year 1913 in Momeik State and royalties amounting to Rs. 1,740 were collected by the Local Government from the native miners.

Kashmir.

The sapphires of Kashmir seem to have been first discovered in 1881 or early in 1882, when a landslip disclosed the sapphire-bearing rocks. The actual locality is a valley near Sumjam in Padar, Zanskar, at an elevation of about 13,500 feet; here the gem has been found both *in situ* in a felspathic igneous rock in a cliff 1,600 feet above the valley, and in the débris in the valley itself. For some years the Kashmir Darbar derived a considerable revenue from the sapphire mines, which were then left unworked for some years on the supposition that they had become exhausted. In 1906 the Kashmir Mineral Company, Ltd., started work under license from the Darbar, and obtained a considerable return of valuable stones. One stone obtained in 1907 was sold for £2,000. Subsequent results, however, were discouraging and no work has been done during the period under review. Owing to the high altitude of the sapphire locality, the ground is under snow and inaccessible for the greater part of the year, work being possible only during the months of July, August, and September.

Salt.

Production.

The average annual production of salt in India during the five years 1909 to 1913 was 1,301,901 statute tons (see table 94), exclusive of that manufactured at Aden, which averaged 110,373 tons per annum during the same period. Throughout the period under review, there was an increased output, as well as an increased import of foreign salt, to meet the greater demand which has followed the reduction of the salt tax to Re. 1 per maund in 1907. The salt manufactured in the country and imported by sea amounted annually to over $1\frac{3}{4}$ million tons. The consumption thus amounted to about $13\frac{1}{2}$ lbs. per head of the population.

[1] *Rec. Geol. Surv. Ind.*, XXXVI, p. 164, (1907).

TABLE 94.—*Production of Salt in India (excluding Aden).*

YEAR.	Statute Tons.	*Metric Tons.*
1909	1,188,073	*1,207,082*
1910	1,485,628	*1,509,398*
1911	1,225,510	*1,245,118*
1912	1,311,015	*1,331,991*
1913	1,299,281	*1,320,069*
Average .	*1,301,901*	*1,322,731*

Sources of Indian salt.

The salt produced in India is obtained from three principal sources, *viz.*, sea-water, subsoil water and lakes in areas of internal drainage, and rock-salt beds. By far the largest amount—about 60 per cent.—is derived from the first source, chiefly in Bombay and Madras, while the rock-salt beds of the Salt Range of Kohat and of Mandi State provide about one-tenth of the Indian output.

Provincial production.

Table 95 shows the provincial production for the five years 1909 to 1913.

TABLE 95.—*Provincial Production of Salt during the years 1909 to 1913.*

PROVINCE.	1909.	1910.	1911.	1912.	1913.	*Average.*
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	*Statute Tons.*
Aden . .	66,535	67,347	100,392	143,681	173,908	*110,373*
Bengal . .	34	22	28	24	25	*27*
Bombay and Sind	443,707	483,322	468,328	546,459	467,578	*481,879*
Burma . .	25,941	22,692	26,235	30,845	30,109	*27,164*
Gwalior State (*a*)	183	52	57	94	114	*100*
Kashmir .	13	16	(*b*)	(*b*)	73	*20*
Madras . .	309,583	464,607	414,521	484,405	348,287	*404,280*
Northern India	408,612	514,917	316,341	249,188	453,095	*388,431*
Total, Statute Tons.	**1,254,608**	**1,552,975**	**1,325,902**	**1,454,696**	**1,473,189**	**1,412,274**
Total, Metric Tons.	*1,274,682*	*1,577,823*	*1,347,116*	*1,477,971*	*1,496,760*	*1,434,870*

(*a*) Relate to official years.
(*b*) Not available.

The returns for provincial production show a marked increase in the amount of salt manufactured at Aden, from 81,996 tons, the average for the years 1904 to 1908, to 110,373 tons a year in the quinquennial period 1909-13. There was also an increase in Bombay from an average of 417,293 tons to 481,879 tons per annum; in Madras from 389,317 to 404,280 tons; in the North Indian lakes and mines from 319,911 to 388,431 tons per annum. The small quantities manufactured in Gwalior and that separated in the manufacture of saltpetre in Bengal are unimportant. The average annual total of salt production has thus risen from 1,249,781 tons for 1904-08 to 1,412,274 tons for 1909-13.

Bombay, as before, is the chief producer, most of the salt being obtained from sea-water, supplemented by the use of sub-soil brine on the border of the Rann of Cutch in an area where, possibly, the brines are directly derived from sea-water. In the Madras Presidency, small quantities of salt are collected in the Masulipatam area, but the rest is manufactured from sea-water. In Upper Burma, salt is obtained from sub-soil brines in the districts of Sagaing, Shwebo, Myingyan, Yamethin, Lower Chindwin, Minbu, Meiktila, and the Hsipaw State. It is often difficult in some of the districts in the 'dry zone' of Upper Burma to obtain deep well water that is not noticeably saline.

Brine wells of Bawgyo.

A special account of the brine wells being worked near Bawgyo in the Hsipaw State has been published by Mr. T. D. LaTouche.[1] The only well being worked at the time was 45 feet deep, and the crude brine included 25·58 per cent. of dissolved salts, which were composed of about 60 per cent. of sodium chloride, 36 per cent. of the sulphate, with small quantities of other salts.

Sub-soil and lake-brine.

The most important of the areas worked for sub-soil and lake brine is the desert region of Rajputana, from which about 250,000 tons of salt are manufactured every year. The whole country is impregnated with salt from the Coast of Cutch and Sind north and north-eastwards to the borders of Delhi district and Bahawalpur State. In many areas of internal drainage there are small temporary salt-lakes which are utilised, as at Sambhar and Didwana; while in other places sub-soil brine is raised, as at Pachbadra. Most of

[1] *Rec. Geol. Surv. Ind.*, XXXV, p. 97, (1907).

the salt in this region appears to be brought in as fine dust by the strong winds which blow from the south-west and south-south-west during the hot weather. These winds blow across the salt-incrusted Rann of Cutch, and carry away the finely-powdered salt in large quantities into the heart of Rajputana, where it becomes fixed when the following monsoon brings rain enough to wash the salt into the small lakes in areas of internal drainage.[1]

Sambhar Lake.

Sambhar, the largest of the Rajputana salt-lakes, covers an area of 60—70 square miles during the monsoon, but dwindles, generally, to a small central puddle by the following March or April. It has been shown by careful sampling at regular intervals that the mud forming the bed of the lake contains on an average 5·21 per cent. of sodium chloride down to a depth of at least 12 feet, and the amount stored in these higher layers of salt cannot thus be less than about 54 million tons. Since the lake was taken over by Government in 1870-71, over 5 million tons of salt have been removed and sold away from Sambhar. During the past five years the average annual distribution amounted to 179,907 tons, most of which went to the United Provinces.

Distribution of Sambhar salt.

Table 96 shows the average annual distribution of Sambhar salt for the five years 1908-09 to 1912-13. From this table it will be noticed that Sambhar has been able to increase its hold on the Central Provinces and Behar in spite of the influx of foreign salt. In the case of the Central Provinces, the average annual amount supplied has risen from 716 tons in 1897-1902 to 4,352 tons in the five financial years ending with 1912-13, while for the corresponding periods in Behar the rise was from 175 to 1,164 tons.

Distribution of Pachbadra salt.

The average annual despatch of salt from Pachbadra during the years 1908-09 to 1913-14 amounted to 27,956 tons, against 20,558 tons in the years 1903-04 to 1907-08. Of this amount, 9,851 tons, or 35 per cent., remained in Rajputana; 9,147 tons, or 33 per cent., went to Central India; 5,446 tons, or 19 per cent., to the Central Provinces; and 3,445 tons, or 12 per cent., to the United Provinces. The distribution is thus very much the same as in the preceding quinquennial period.

[1] T. H. Holland and W. A. K. Christie, *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 154—186, (1909).

TABLE 96.—*Average annual distribution of Sambhar Salt.*

—	1903-04 to 1907-08.		1908-09 to 1912-13.	
	Quantity.	*Per cent.*	Quantity.	*Per cent.*
	Tons.		Tons.	
United Provinces	114,711	*68·9*	117,883	*65·5*
Rajputana	23,490	*14·1*	27,601	*15·3*
Central India	16,058	*9·6*	20,154	*11·2*
Punjab and North-West Frontier Province.	10,302	*6·2*	8,753	*4·9*
Central Provinces	1,586	*1·0*	4,352	*2·4*
Behar	371	*0·2*	1,164	*0·7*
Average Total .	**166,518**	*100·0*	**179,907**	*100·0*

Production of rock-salt.

There has been an increase in the average annual output of rock-salt from 120,439 tons in the period 1904-08 to 150,384 tons per annum in 1909-13; this represents 11·2 per cent. of the total production of India, excluding Aden. The details are shown in table 97, from which it will be seen that the increase in production of rock-salt is due to the mines on the Salt Range, which gave an average annual output of 128,247 tons in 1909-13, against 100,839 tons in the preceding period. The changes in Kohat and Mandi State are less than the annual variations.

A general account of the occurrences of rock-salt in the Punjab and North-West Frontier Province will be found in a previous Review (*Records*, Vol. XXXII, pages 83, 84) and in a recent paper by Dr. W. A. K. Christie published in the *Records* (Vol. XLIV, pages 241—264).

TABLE 97.—*Production of Rock-Salt during the period 1909-13 compared with the period 1904-08.*

YEAR.	Salt Range, Punjab.	Kohat, North-West Frontier.	Mandi State.	**Total.**	*Percentage of total salt production of India.*
	Statute Tons.	Statute Tons.	Statute Tons.	**Statute Tons.**	
1909	126,987	15,875	3,857	**146,719**	*12·3*
1910	119,868	17,098	3,671	**140,637**	*9·5*
1911	124,605	17,585	3,996	**146,186**	*11·9*
1912	131,234	22,582	3,378	**157,194**	*12·0*
1913	138,542	19,099	3,542	**161,183**	*12·4*
Average for 1909-13	**128,247**	**18,448**	**3,689**	**150,384**	**11·5**
Per cent. of average total (1909-13).	85·3	12·3	2·4	..	..
Average for 1904-08 .	*100,839*	*15,655*	*3,945*	*120,439*	*10·3*
Per cent. of average total for 1904-08.	83·7	13·0	3·3	..	..

Imports and origin of foreign salt.

There was a considerable increase, amounting to nearly 14 per cent., in the imports of foreign salt. The chief features of these imports during the period under review are the steady decline in imports from the United Kingdom, the marked increase in the trade with Spain, the considerable increase in that with Aden and Egypt, and the introduction of a new source of supply, Italian East Africa.

Most of the salt imported is landed at Calcutta, the next larger importer being the Province of Burma, which, however, only takes a little over 60,000 tons a year.

TABLE 98.—*Imports of Salt during 1908-09 to 1913-14 compared with the period 1903-04 to 1907-08.*

IMPORTED FROM	1903-04 to 1907-08.		1908-09 to 1913-14.	
	Quantity.	*Per cent. of total.*	Quantity.	*Per cent. of total.*
	Tons.		Tons.	
United Kingdom	219,347	*45·2*	164,541	*29·8*
Aden	69,903	*14·4*	92,295	*16·7*
Spain	35,744	*7·4*	91,509	*16·6*
Arabia	60,338	*12·4*	65,066	*11·8*
Egypt	26,901	*5·6*	57,162	*10·3*
Germany	67,824	*14·0*	56,833	*10·3*
Italian East Africa	..	..	23,875	*4·3*
Other countries	4,883	*1·0*	1,018	*0·2*
Average Annual Total	**484,940**	*100·0*	**552,299**	*100·0*

Potash salts.

The presence of potash salts associated with the halite of the Salt Range has been known for a considerable period, and an attempt was recently made to ascertain the economic possibilities of the deposits. Dr. W. A. K. Christie visited the mines both at Khewra and at Nurpur, and found that potash-bearing seams were fairly numerous, and ranged from ½ to 2 metres in thickness and contained from 6·8 to 14·4 per cent. of K_2O. Part of his report[1] is quoted below :—

Potassium bearing salts were discovered in the Mayo Mines in 1873 by H. Warth. The specimens collected by him, consisting of mixtures of kieserite, sylvite and langbeinite, with common salt, have been described by a number of writers.[2] The deposit, however, was lenticular and the total quantity obtained was only 15 maunds (560 kg.).[3]

[1] Published in *Rec. Geol. Surv. Ind.*, XLIV, p. 243, (1914).

[2] G. Tschermak, *Min. Mitt.*, 1873, p. 135.
H. Warth, *Öst. Zeit. f. Bergu. Hüttenwesen*, XXIV, p. 408, (1876).
A. Tween, *Mem. Geol. Surv. Ind.*, XIV, p. 80, (1878).
F. R. Mallet, *Mineral. Mag.*, XII, p. 159, (1900).

[3] F. R. Mallet, 'Manual of the Geology of India,' part 4, p. 33, (1887).

On account of the great economic value of salts of potassium, chiefly for agricultural purposes, and the restricted area of their production,—practically the whole of the world's supply comes from the North German mines,—prospecting operations were carried out in the mines of the Salt Range, and further deposits have been found, in the Mayo Mines at Khewra and at Nurpur.

. . . .

The Department of Northern India Salt Revenue, by which the mines are worked, has hitherto been concerned only with the recovery of marketable salt, of which there exists an unlimited quantity; they have, therefore, naturally altered the direction of their workings on striking a seam of marl or impure salt of any considerable thickness, and before the underlying strata were exposed. Most of the occurrences of potassium salts are overlain by marl seams, and the exposures, consequently, are neither frequent nor easily followed out. . . . .

A list of the localities where potassium salts were found in these mines is given below. The numbers refer to the chamber series, there being a distance of 21·3 metres in a direction N. 60° E. from the median line of chamber n to that of chamber $n + 1$. The localities are characterised in terms of the phraseology locally current:—

(*a*) No. 9, 3 metres S. of new tram, below the top seam of Pharwala-Sujowal marl.
(*b*) No. 9, 33·5 metres from entrance of drift N. of Buggy.
(*c*) No. 9-10 pillar, 4 metres S. of new tram, 0·5 metre below marl seam.
(*d*) No. 10, drift block Pursang, 1 metre below the highest seam of the hundred-foot marl.
(*e*) No. 12, Pharwala exploring drift, 33 metres from the mouth.
(*f*) No. 12, Pharwala exploring drift, 83 metres from the mouth.
(*g*) No. 13, Pharwala, end of ten-foot drift underlying marl seam below 544 salt.
(*h*) No. 14, Pharwala, S. end of drift.
(*i*) No. 14-15 pillar, N. old tram.
(*j*) No. 16, Pharwala drift, immediately below hundred-foot marl.
(*k*) No. 16, Pharwala drift, 1·2 metres below hundred-foot marl.
(*l*) No. 19, Buggy-Sujowal, below the second of the marl seams of Pharwala Sujowal marl.
(*m*) No. 22, Pharwala, mouth of exploring drift.
(*n*) No. 22, Pharwala, 53 metres from mouth of exploring drift.
(*o*) No. 26, Pharwala, mouth of old drift, underlying highest marl seam.
(*p*) No. 26, Pharwala, Nur Mahomed's drift, in fourth highest marl seam.
(*q*) No. 27, Buggy, beneath stairway at S. end.
(*r*) No. 29, below Buggy false marl.
(*s*) No. 30, Buggy, below Buggy false marl.
(*t*) No. 31, Buggy, below false marl.
(*u*) No. 32, Buggy, below Buggy false marl.

In many of these localities the potassium bearing deposits are too small to be of any commercial value. The most important are *e*, *f*, *i*, *m*, *n*, *s* and *u*. Of these *e*, *i* and *m* are probably exposures of one seam which we may call the Sujowal-Pharwala seam, and *f* and *n* form parts of another, which we may call the Pharwala seam. The third occurrence of any importance, which may be called the Buggy seam, extends from *q* to *u* and is easily traceable.

Average samples taken across the seams *e*, *i*, *m*, *n* and *u* contained the following percentages of K_2O :—

Seam.	True thickness.	K_2O.
	Metres.	Per cent.
e	1·98	6·8
i	1·17	9·6
m	1·22	8·0
n	2·44	7·7
u	0·69	14·4

With the data available it is impossible to estimate the quantities of potassium salts which these exposures represent, but one can form a rough idea of their order of magnitude. In addition to the exposures at *e*, *i* and *m*, the Sujowal-Pharwala seam is found at *c*, where it is about 0·5 metre thick, and at *d*, where it is thinning out from a thickness of 1 metre. The exposure at *d*, 0·4 metre, is probably the same bed and it is found again at *p*, 0·2 metre in thickness. These data show that the seam decreases in thickness as it is followed up the rise, so we shall leave out of consideration exposures higher than *i*. *i* is at a distance of about 53 metres N.-N.-W. from the line joining *e* and *m*, whose distance apart is 220 metres. The thickness of the bed is 1·98 metres at *e*, 1·17 metres at *i*, and 1·22 metres at *m*. If we take the average of these (1·46) as the mean thickness of the seam, assume that the deposit extends to *i* with the breadth which it has between *e* and *m*, and take its specific gravity as 2·3, it would contain about 40,000 metric tons, carrying, say, 3,000 tons of K_2O. The figures are probably underestimates, for, although the bed thins out on the rise, it probably increases in thickness with depth, the lowest exposure, *e*, being also the thickest. What has been called the Pharwala seam has been met with only at two points, *f* and *n*, about 220 metres apart, both in low level exploring drifts ; as it is not even certain that they belong to the same bed, it might be unwise to do more than point out the favourable indications they afford. That at *f* is 2·4 metres thick ; that at *m* is also 2·4 metres thick, and carries 8·0 per cent. of K_2O. The Buggy seam at *s* is 0·95 metre in thickness, and at *u*, about 45 metres distant ; it is 0·61 metre. The deposit thins out as it is traced up the rise, the lowest exposure, *s*, being the thickest. At *r*, for instance, whose line of strike is some 60 metres up the rise from that of *s*, it is only a few centimetres. The quantity of the deposit in sight, therefore, is not more than a few hundred tons. No excavation further down the dip had been made at the time of my visit, and the basin of deposition may, of course, be deeper at other parts.

A potash bed was found in the small mine in the magnificent gorge of Nilawan about 3 km. S.-S.-E. of the village of Nurpur, from which it derives its name, and 18 km. from the railway at Lilla, whither the rock salt is transported on camels.

It strikes N. 40° E. and has a south-easterly dip of about 75°. A boring was made through the seam and its true thickness ascertained to be about 1·9 metres. The material from the borehole was carefully collected and may be taken as nearly approaching an average sample. It contained 13·6 per cent. of K_2O.

The deposits are all very similar in general character; they contain common salt, kieserite ($MgSO_4,H_2O$), langbeinite ($K_2SO_4,2MgSO_4$), sylvite (KCl) and kainite ($KCl,MgSO_4,3H_2O$). Analyses of average samples from the Pharwala-Sujowal, Buggy, and Nurpur seams are given below:—

——	Pharwala-Sujowal	Buggy.	Nurpur
K	8·0	11·9	11·3
Na (calculated)	21·5	10·0	9·2
Mg	4 8	8 9	9·0
Cl	37·5	23·3	21·4
SO_4	22·9	39 3	39·5
H_2O	4·9	7·1	9·3
	99·6	100·5	99·7

The difficulties of obtaining pure potassium salts from such mixture are considerable, and they differ in mineralogical composition so markedly from the salt usually mined in Europe that analogous methods of treatment are inapplicable. Crystallisation from aqueous solution at any temperature is not likely to be feasible. Were magnesium chloride ever available, the method of W. Feit,[1] by which the material is treated with a hot saturated solution of salt with a sufficient quantity of magnesium chloride to prevent the solution of magnesium sulphate, might be employed, but in the present circumstances it would probably be preferable to remove the magnesium sulphate with lime [$MgSO_4 + Ca(OH)_2 = Mg(OH) + CaSO_4$], limestone and coal of a quality good enough for burning purposes being readily available in the neighbourhood. The operations would comprise the solution of the raw material, preferably with the help of hot mother liquors, the addition of a slight excess of slaked lime of the consistency of a thin cream, the agitation of the mixture until the precipitation of the magnesium hydroxide was complete, and the filtration of the soluble portion, now consisting of chlorides and sulphates of sodium and potassium, from the insoluble calcium sulphate and magnesium hydroxide. The filtrate would then be concentrated at boiling temperature until saturated, allowed to cool and the mother liquor drained away from the crystalline product formed,

[1] *Kali*, III, p. 313, (1909).

the latter being subsequently recrystallised. It is of course dangerous to draw conclusions from laboratory tests as to what would occur when the same reactions are carried out on an industrial scale, but it may be recorded that from a solution in water of 150g. of a sample from the Nurpur seam, the analysis of which is given below in the first column, 20·0g. of the product whose composition, when dried, is shown in the second column, was obtained on cooling to 10° C. the boiling saturated solution, freed as above from magnesium salts.

—	Raw material.	Concentrate.
K	11·3	44·7
Na	9·2	4·3
Mg	9·0	trace.
Cl	21·4	35·6
SO_4	39·5	15·5
H_2O	9·3	trace.
	99·7	100·1

This, it is true, represents a recovery of but 53 per cent. of the total potassium in the raw material, but by judicious use for dissolving purposes of the mother liquors obtained on crystallising, the yield could probably be increased. The mining costs would be comparatively low; they would, however, considerably exceed the Re. 1-13 per ton expended on recovery of the more easily mined rock salt. It is difficult to estimate the value of the products that would be recovered. High grade potassium sulphate is sold in Calcutta at about Rs. 200 per ton, say Rs. 90 per ton of K, so that were the extensiveness of any of the seams definitely proved, there would appear to be an ample margin for extraction and freight charges.

Saltpetre.

Condition essential for the formation of saltpetre.

For the formation of saltpetre in a soil the necessary conditions are (1) supplies of nitrogenous organic matter, (2) climatic conditions favourable to the growth and action of Winoradsky's so-called nitroso and nitro bacteria, converting urea and

ammonia, successively, into nitrous and nitric acids, (3) the presence of potash, and (4) meteorological conditions suitable for the efflorescence of the potassium nitrate at the surface. An ideal combination of these necessary circumstances has made the Behar section of the Gangetic plain famous for its production of saltpetre.

In this part of India we have a population of over 500 per square mile, mainly agricultural in occupation, and thus accompanied by a high proportion of domestic animals, supplying an abundance of organic nitrogen. With a mean temperature of 78° F., confined to an annual range of 68°, and for a large part of the year when the air has a humidity of over 80 per cent., with a diurnal range not exceeding 8° above or below 84° F., the conditions are unusually favourable for the growth of the so-called 'nitrifying' bacteria.

With a population largely using wood and cow-dung for fuel, the soil around villages naturally would be well stocked with potash, and finally, with a period of continuous surface desiccation following a small rainfall, the sub-soil water, brought to the surface by capillary action in the soil, leaves an efflorescence of salts, in which, not surprisingly, potassium nitrate is conspicuous. Under these conditions Behar has for many years yielded some 20,000 tons of saltpetre a year.

System of manufacture.

The system of manufacture has been very frequently described in detail,[1] and consists essentially in dissolving out the mixed salts contained in soil around villages, and effecting a first rough separation of the two most prominent salts—sodium chloride and potassium nitrate—by fractional crystallisation. The impure sodium chloride is consumed locally, whilst the saltpetre is sent to refineries for further purification before export.

Production and export.

The returns for production are so manifestly imperfect, being considerably below the amounts of export, that the export figures must be taken as the only index, though still an imperfect one, to the extent of the manufacture. The export figures for the past five years are given in table 99, showing an average annual export of 331,531 cwts., valued at £252,634.

[1] The Indian Saltpetre Industry, by J. W. Leather and J. N. Mukerji. *Agric. Res. Inst., Pusa*, Bull. No. 24, (1911).

Variations in exports.

For many years past, there has been a small but steady tendency towards decrease in the output of saltpetre in India. The decrease, however, is only small, as is the reduction in the amount annually exported, in spite of the constantly increasing production in other parts of the world of nitrates, both derived from natural deposits and artificially manufactured, and of wholesale changes in the substances used for manures and for the manufacture of explosives. For the six years 1878-83 the average quantity of saltpetre exported amounted to 405,568 cwts. a year; for a similar period ten years later, namely, 1888 to 1893, the average annual exports were 389,989 cwts.; for the period 1897-98 to 1902-03 the average annual exports were 382,353 cwts., valued at £262,592, and for 1903-04 to 1907-08, 358,989 cwts., valued at £265,135. As will be seen from table 99, there was a still further decline during the period under review. The highest values, ranging from about £600,000 to nearly £900,000 a year, occurred at the time of the American Civil War from 1860 to 1864, but saltpetre was then an essential constituent of explosives and India had almost a monopoly of supplies.

TABLE 99.—*Total Exports of Saltpetre by Sea and Land during the years 1908-09 to 1912-13.*

YEAR.	QUANTITY.		Value.	Value per cwt.
	Cwts.	*Metric tons.*		
			£	Shillings.
1908-09	400,271	*20,334*	302,351	15·11
1909-10	358,232	*18,198*	260,936	14·57
1910-11	327,661	*16,645*	248,154	15·15
1911-12	274,562	*13,948*	214,399	15·62
1912-13	296,928	*15,083*	237,331	15·98
Average .	*331,531*	*16,842*	*252,634*	*15·24*

Distribution of exported saltpetre.

During the period under review, there has been a marked change in the distribution of the Indian exports of which 80 per cent. formerly went to the United States, the United Kingdom and Hongkong. The share of those markets has now fallen to 70 per cent., while the amount taken by Ceylon has more than doubled and that taken by Mauritius has nearly doubled. The exports to France have fallen from over 21,000 cwts. annually to less than 10,000 cwts. There is thus a tendency for reduction in trade with distant countries and an increase with Indian Ocean ports. The figures for the distribution of Indian saltpetre are given in table 100.

TABLE 100.—*Average Distribution of Saltpetre exported by Sea during the years 1908-09 to 1912-13.*

EXPORTED TO	Average annual quantity.	*Per cent. of average total.*
	Cwts.	
United States	90,269	27·2
Hongkong	78,561	23·7
United Kingdom	63,478	19·2
Mauritius	41,043	12·4
Ceylon	25,802	7·7
Straits Settlements	9,789	3·0
France	9,685	2·9
China (*a*)	6,520	2·0
Other countries	6,351	1·9
Average Total for the years 1908-09 to 1912-13	**331,498**	*100·0*

(*a*) Exclusive of Honkong and Macao.

Provincial shares in the exports.

Calcutta is still, as it always has been, the chief port through which saltpetre leaves India, the exports during the period under review having amounted to 98·46 per cent. of the total, as compared with 98·6 per cent. during the previous

period. Of the small remaining amount exported, 0·91 per cent. left *viâ* Karachi. The average annual exports from the different provinces have been as follows during the years 1908-09 to 1912-13 :—

	Cwts.
Bengal	326,399
Sind	3,018
Bombay	2,055
Madras	21
Burma	5
TOTAL	331,498

The Calcutta supply is obtained mainly from Behar, as shown in table 101, which has been compiled from returns published each year by the Commissioner of Northern India Salt Revenue.

TABLE 101.—*Average Annual Imports of Saltpetre into Calcutta for the years 1908-09 to 1912-13.*

OBTAINED FROM	Average annual quantity.	*Per cent. of average total.*
	Cwts.	
Behar	204,521	*58*
United Provinces	108,662	*30·8*
Punjab	37,977	*10·8*
Other provinces	1,225	*0·4*
Average Total	**352,385**	*100·0*

Trans-frontier imports.

Only very small quantities of saltpetre for chemical and medicinal purposes are imported into India by sea, but a considerable quantity comes from Nepal. During the past five years the imports from Nepal have, as shown below, averaged 9,172 cwts., as compared with 4,156 cwts. during the previous five years.

Saltpetre imported from Nepal.

	Cwts.
1908-09	10,433
1909-10	8,479
1910-11	12,333
1911-12	7,902
1912-13	6,714
Average	9,172

The annual values returned for the total imports give an average of £4,596, or of 9·96 shillings per cwt.

Tin.

Unworked occurrences.

Tin has a wider distribution than is generally recognised, and its minerals are often overlooked through the difficulty of distinguishing them from other heavy minerals. Isolated crystals of cassiterite or tinstone have been found in pegmatites associated with gadolinite in the Palanpur State,[1] whilst in the Hazaribagh district of Chota Nagpur instances have been recorded of the accidental production of tin from river sands by the native iron smelters, in addition to the known occurrences of ores *in situ.* The latter are two in number —Nurunga and Chappatand—and the ore occurs in the unusual form of a cassiterite-granulite, which is very rich in tin. The Nurunga occurrence has been opened up a little during the period under review, and has been worked on a small scale by Mr. P. N. Bose.[2]

Worked deposits.

The persistent attempts to work tin in Burma reported in previous reviews have now resulted in the definite establishment of the industry, and the value of the output rose from £10,992 in 1908 to over £50,000 in 1912, the average annual value for the period under review being £30,100. The ore is cassiterite and is obtained by washing alluvial gravels in the Mergui and Tavoy districts of South Burma, and in the Bawlake State, Karenni, Southern Shan States. Several companies have been formed to work tin-ore in Tavoy and Mergui,

[1] T. H. Holland, *Rec. G. S. I.*, XXXI, p. 43, (1904).
[2] L. L. Fermor, *op. cit.*, XXXIII, p. 235, (1906); XLII, p. 79, (1912).

but with the exception of two, the Hindu Chaung Dredging Company and the Burma Development Syndicate, who are employing machinery, work is carried on only on a small scale and by native methods. Other dredging propositions, however, are in contemplation, and it is to be hoped that before long the tin resources of Burma will be seriously exploited.

TABLE 102.—*Production of Tin and Tin-ore in the Indian Empire, during the years 1909-13.*

—		MERGUI.		TAVOY.		SOUTHERN SHAN STATES.		HAZARIBAGH.		**Total.**	
		Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	**Quantity.**	*Value.*
		Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£
1909	Tin .	..	..	..	..	..	..	..	..	..	*9,645*
	Tin-ore .	1,665	*9,611*	7	*34*	..	..	..	..	**1,672**	
1910	Tin .	1,507	*10,935*	..	..	..	..	3	*26*	**1,510**	*18,578*
	Tin-ore .	1,767	*7,589*	6	*28*	..	..	..	..	**1,773**	
1911	Tin .	1,764	*15,543*	..	..	..	..	3	*27*	**1,767**	*24,931*
	Tin-ore .	1,141	*6,101*	802	*3,260*	..	..	..	..	**1,943**	
1912	Tin .	2,756	*28,224*	1,258	*7,966*	..	..	..	..	**4,014**	*50,944*
	Tin-ore .	2,261	*9,781*	30	*165*	1,202	*4,808*	..	..	**3,493**	
1913	Tin .	2,336	*24,419*	1,314	*8,279*	..	..	..	..	**3,650**	*46,384*
	Tin-ore .	1,717	*7,703*	21	*122*	1,675	*5,861*	..	..	**3,412**	
Average	*Tin* .	*1,673*	*15,824*	*514*	*3,249*	..	..	*3*	*26*	*2,188*	*30,096*
	Tin-ore	*1,710*	*8,157*	*173*	*722*	*575*	*2,134*	..	..	*2,458*	

Production.

Table 102 shows the production of tin in Burma during the five years under review, the value of the ore and metal produced having risen from £9,645 in 1909 to £50,944 in 1912. There was a

slight fall to £46,384 in 1913. As already stated the ore is won chiefly from stream doposits and most of it is smelted locally in small native furnaces. A small proportion of ore, however, is exported in the form of 70 per cent. concentrates (see table 103), almost the whole export going to the Straits Settlements. Comparison of table 102 with table 103 will show that all the material returned as 'tin ore' is exported, the rest being converted locally into block tin, which is consumed either in Burma or in India. The average annual value of the ore exported has risen from £3,053 in 1904-08 to £11,283 in the period under review.

TABLE 103.—*Exports of Burmese Block Tin and Tin-ore for the years 1908-09 to 1912-13.*

YEAR.	BLOCK TIN.		TIN-ORE.		**Total.**	
	Quantity.	*Value.*	Quantity.	*Value.*	**Quantity.**	*Value.*
	Cwts.	£	Cwts.	£	**Cwts.** (tin ore) (*a*)	£
1908-09 . .	77	*375*	580	*1,664*	**696**	*2,039*
1909-10 . .	33	*224*	2,300	*9,362*	**2,350**	*9,586*
1910-11 . .	33	*251*	2,400	*10,269*	**2,450**	*10,520*
1911-12 . .	15	*147*	2,680	*13,198*	**2,702**	*13,345*
1912-13 . .	..	..	4,280	*20,927*	**4,280**	*20,927*
Average .	*32*	*199*	*2,448*	*11,084*	*2,496*	*11,283*

(*a*) 3 cwts. of tin-ore are assumed to be equivalent to 2 cwts. of block tin.

Imports of block-tin.

But the amount of Burmese tin consumed in the Indian Empire is a small quantity compared to the requirements of the country. Table 104 shows the amounts of foreign unwrought block tin which have been consumed in India during the period under review, and in addition to these quantities, smaller quantities of tin-plates are imported. By far the largest quantity of block tin imported into India comes from the Straits Settlements. Out of the average total of 35,888 cwts., the quantity coming from the Straits averaged 32,305 cwts. per annum. A curious feature connected with the imports is the fact that the quantities of foreign tin imported have not increased since statistics of weight were first recorded in 1875-76. In that year the tin imported was reported to amount to 36,159 cwts., of which 31,479 cwts. came from the Straits.

TABLE 104.—*Consumption of Foreign Block Tin in India.*

YEAR.	IMPORTS.		Re-exports.	**Consumption.**
	Quantity.	*Value.*		
	Cwts.	£	Cwts.	**Cwts.**
1908-09	36,855	*280,644*	3,205	**33,650**
1909-10	38,375	*292,355*	4,343	**34,032**
1910-11	36,355	*295,455*	2,052	**34,273**
1911-12	36,321	*349,291*	2,181	**34,143**
1912-13	31,536	*335,733*	2,542	**28,294**
Average	*35,888*	*310,696*	*2,865*	*33,048*

Mode of occurrence and economic considerations.

The country in which the Burmese tin-ore is found forms a belt—comprising Karenni, Tavoy and Mergui—linking Yunnan, the south-west province of China, in which tin-mining is said to support a large population,[1] to the well-known tin-ore deposits of the Straits Settlements (now the Federated Malay States) to the south, from which, in 1912, about 49 per cent. of the world's supply of tin was obtained. In both Burma and Malaya by far the larger proportion of the ore is won from alluvial deposits, but a beginning has been made in working lode tin in both countries.

During 1907 and 1908 Mr. J. J. A. Page of the Geological Survey of India was engaged in investigating the tin deposits of the Mergui and Tavoy districts. The results of his investigations are summarised in the Annual Reports of the Department.[2]

Mergui district.

In the Mergui district, the principal hill ranges have a north to south trend and are composed mainly of granite, with flanking hills cut out largely of unfossiliferous schists, slates, sandstones, and quartzites, belonging to the so-called Mergui series. The granites appear to be intrusive into the sedimentary rocks; and are exposed in a series of bosses that do not form a continuous outcrop. There appears to be more than one generation of granitic rocks, and they are traversed by quartz-porphyry dykes. Isolated patches of strata, probably Tertiary in age, are found resting unconformably on the highly inclined Mergui slates and quartzites. The country is largely covered with laterite and recent alluvial deposits, and is very heavily jungle-clad; roads are scarce and most of the transport is effected along the numerous creeks.

The only tin-ore worked is cassiterite, which is widely distributed throughout the district and is invariably found near the granitic hills. The mineral is found under the following four conditions:—

(1) *As a constituent of decomposed pegmatite rich in tourmaline and muscovite, known locally as "kra";* at numerous localities.

(2) *In massive quartz-segregations in and on the outskirts of granitic hills.* Some of these segregations are several feet in

[1] A. Leclère, 'Exploration géologique des Provinces chinoises voisines du Tonkin.' *C. R., 29eme Session, Assoc. Fr.*, 1900, ii, pp. 916—926. Abs. *Trans. Inst. Mining Engineers*, XXII, 1901-02, p. 715. Also :—
W. F. Collins, 'Tin-Production in the Province of Yunnan, China,' *Bull. No. 63, Inst. Min. Met.*, pp. 1—14, (1910).

[2] *Rec. Geol. Surv. Ind.*, XXXVII, pp. 38—41 (1908); XXXVIII, pp. 53—57, (1909).

thickness, and sometimes carry also wolfram, pyrite, and chalcopyrite, as for example at North Hill near Maliwun.

(3) *In quartz veins and stringers in ground adjacent to decomposing pegmatite.*

(4) *Hill-side talus accumulations due to the disintegration of classes (1), (2), and (3),* extending to gravel deposits along the stream valleys and in alluvial flats. These form the deposits most generally worked by the Chinese and Siamese immigrants.

The tin mines are divided by Mr. Page into the following groups :—

(1) *Mergui township ;* the tin-stone averages 3 pounds per cubic yard.

(2) *Tenasserim township ;* Thabalik, Tagu, and Thendaw groups of mines ; in one of the Thabalik mines the pay dirt was 10 feet thick and contained 15 pounds of tin-stone per cubic yard.

(3) *Bokpyin township ;* Manoron, Yengan, Bokpyin, and Karathuri groups ; there are many more tin mines in this township than in the whole of the rest of the district.

(4) *Victoria Point ;* Maliwun and Banhuni groups ; it is in the Maliwun area that the concession of the Burma Development Company is situated.

Most of the tin won in this district is obtained by Chinese and Siamese working on the alluvial deposits by ground-sluicing methods. The tin concentrates obtained are in some cases smelted locally and in others exported as ore to the Straits.

As the general result of his work is, Mr. Page found [1] that cassiterite was widely distributed in the district, existing in quantities that should be payable on either side of the granitic axes of the chief ranges. The bulk of the cassiterite was formed in the numerous pegmatite intrusions into granites and other rocks, and the deposits being worked had been derived from the disintegration of the pegmatites. It was considered possible that in some areas systematic prospecting would prove the existence of deposits suitable for dredging.

Since Mr. Page's visit, a considerable amount of interest has been shown in the district and attempts have been made to exploit

[1] Agreeing thus with his predecessors, Dr. T. Oldham (1855), Mr. Mark Fryer (1871), and Mr. T. W. H. Hughes (1899). See Hughes' 'Tin-mining in Mergui District,' *Rec. Geol. Surv. Ind.*, XXII, pp. 188—208, (1889). Also a separate report by Hughes published in Rangoon in three parts, (1889-91).

the deposits. Except at Maliwun, however, work was carried on during the period under review chiefly on primitive native principles, but the value of the annual output of block tin and of ore rose from £9,611 in 1909 to over £32,000 in 1913.

Of the syndicates and companies formed to work tin in Mergui only one need be mentioned, the Burma Development Syndicate, Ltd., registered in London on 8th April 1903, with a capital of £5,000. A prospecting license was taken out on behalf of the Syndicate by Mr. A. B. Snow on the 13th March 1905 over the Maliwun property; this was converted to a mining lease on 1st July 1906. On December 5th, 1912, the Company was reconstructed, with an authorised capital of £70,000 in 140,000 shares of 10*s*. each. The Syndicate's concession is 3 square miles (1,955 acres) in area, and includes Khow Ma'ung Hill (Centre Hill) and North Hill—granite hills containing stanniferous quartz segregations. The Syndicate also holds 40 acres of alluvial ground and 900 acres on which rubber has been planted. With the tin-stone on these concessions there is a certain proportion of wolfram.

Tavoy district.

After the discovery by Mr. Page of wolfram in Tavoy, there was a considerable rush to that district and during the latter part of the period under review applications for mineral concessions in the district suddenly rose to over 100 per annum. Wolfram and tin-ore were the minerals chiefly sought, and the former more generally than the latter. Most of the work done was carried out by primitive native methods, but syndicates were also formed with a view to tin-dredging, both in the Heinza basin and in the valley of the Hindu Chaung. To exploit the latter locality the Hindu Chaung Tin Dredging and Mining Company was floated in Australia in February 1910. The authorised capital of the Company was £150,000 of which there were issued 65,000 ordinary shares at £1 fully paid, and 42,590 ordinary shares at £1, of which 13*s*. were paid up. The Company were fortunate in securing the services of Messrs. J. R. and H. W. Booth, who succeeded, in spite of the great natural difficulties of the country, in transporting and erecting a suction dredge on the alluvial flats of the stream at about 40 miles to the east of Tavoy town. Unfortunately, as not infrequently happens in the case of the pioneers of a new industry, in spite of promising prospects in the initial stages the most favourable local conditions for working had to be learnt by experience and the heavy costs of labour and

transport have compelled the company to go into liquidation. The enterprise, however, has not been finally abandoned and the next quinquennial period may see its resuscitation. The sands of the Hindu Chaung are of an interesting nature; a sample presented by Mr. Booth was found to contain, in addition to cassiterite and wolfram, large quantities of topaz, both yellow and white, some zircon, garnet and magnetite.

Tungsten.

Uses of tungsten.

The valuable properties of tungsten steel have been known for over half a century, but it is only within the last few years that the metal and its various salts and alloys have been brought into general use. It has quite recently been discovered that although normally hard and brittle, the metal can be rendered perfectly ductile by means of repeated heating and swaging; it can thus be drawn out into wires of extreme fineness and remarkable strength, a wire of a diameter of $\frac{1}{250}$ inch having been found to stand a strain of nearly 200 tons per square inch. This property renders the wire suitable for the manufacture of filaments for incandescent electric lamps, the ductile wire now replacing the filament formerly made of the compressed powder of the metal.

The chief value of tungsten, however, lies in the fact that when it is added to steel, the latter acquires the property of 'self-hardening' and requires no tempering; it also retains its hardness at a red heat and is thus superior to carbon steel for the manufacture of high-speed cutting tools. Over four-fifths of the total outturn of tungsten is now absorbed in the manufacture, chiefly in the electric furnace, of ferro-tungsten containing between 50 and 85 per cent. of tungsten and amounts of carbon varying from $\frac{1}{2}$ to 5 per cent. The steel of cutting tools contains from 6 to nearly 20 per cent. of tungsten, a small percentage of carbon and small quantities of chromium and vanadium.

Tungsten is also used in the form of one or other of its salts—the tungstates—in various industrial processes, such as dyeing, fire-proofing, the differential analysis of tanning materials, and the manufacture of bronze colours.

Production.

Until comparatively recent years, the chief source of supply was the United States, but some five years ago the first serious attempt was

made to develop the wolfram deposits of the Indian Empire, and Lower Burma now heads the list as the world's greatest producer. The total production of the world is about 8,000 tons per annum of concentrates carrying from 60 to 70 per cent. of tungstic trioxide, WO_3. Of this Burma produces one quarter.

Wolfram in Burma.

The first record of the occurrence of wolfram in Burma dates back nearly three quarters of a century, to the year 1841, when Captain Tremenheere, one of the Hon'ble East India Company's servants, visited Mergui to report on the prospects of working tin; he found that the tin-ore washed in certain places was of an inferior grade owing to a large admixture of wolfram,[1] and although subsequent references to the presence of this mineral both in Tenasserim and in Karenni are not infrequent, no steps were taken to prospect for or to exploit the deposits until Mr. J. J. A. Page, a member of the Geological Survey, was deputed to Lower Burma to report on the local tin-mining industry. In the course of his investigations near Tavoy, Mr. Page discovered the wolfram-bearing lodes of Pagaye which have since yielded such large quantities of ore. After the Geological Survey had drawn attention to this occurrence[2] prospecting was taken up by the general public and during the five years, 1909-13, Lower Burma has produced over 5,000 tons of concentrates having a value of nearly £400,000; the years 1911-13 were responsible for practically the whole of this output, that of 1909 being only 7 tons, and of 1910, 395 tons; the industry is therefore now little more than four years old, although the annual production has attained to nearly 2,000 tons of concentrates.

The ore, which always consists of wolframite, occurs primarily in veins composed chiefly of quartz but carrying also columbite, tourmaline, molybdenite and, very occasionally, cassiterite.[3] These veins traverse granite and a series of metamorphosed sediments composed of slate, schist and quartzite, and known as the Mergui series. The granite, which carries locally considerable quantities of cassiterite, is younger than, and intrusive in, the Mergui series. It has been found that in Lower Burma when quartz veins carry wolfram, they are usually free from cassiterite, the latter mineral occurring in separate quartz-cassiterite lodes as well as in the granite.

[1] *Jour. As. Soc. Bengal*, X, p. 849, (1841); *op. cit.*, XI, pp. 847—9, (1842).
[2] *Rec. Geol. Surv. India*, XXXIX, p. 279, (1914).
[3] A. W. G. Bleeck: *Rec. Geol. Surv. India*, XLIII, p. 48, (1913).

Occasionally, however, both tin and wolfram are found in the same lode, but this association appears to be exceptional.

The wolfram-tin-bearing belt of granite and metamorphic rocks runs on northwards from Mergui and Tavoy into the Southern Shan States and is being exploited in Bawlake State; it is also said to occur further north in the neighbourhood of Kalaw.

Indian occurrences.

In India wolfram has been found in various localities, but hitherto with one exception in only small quantities. In the Nagpur district a few hundredweights have been extracted from quartz veins traversing the Dharwar rocks of Agargaon, but the deposit has shown no signs of being more than insignificant. In Trichinopoli district isolated specimens have been found at Kadavur and Ururarkarad. The most recent discovery is that of a deposit in Rajputana at Degana on the Jodhpur-Bikaner Railway.[1] The ore occurs with quartz and biotite in veins traversing granite and although no evidence of a large deposit has yet been obtained, the result of such investigations as have been made is sufficient to warrant thorough prospecting of the locality.

Although the expansion of the wolfram-mining industry in Burma has been extremely rapid and the profits very great, the methods employed in exploitation have for the most part been of the most primitive description. In addition to the quartz-wolframite lodes, float deposits provide a certain amount of ore, but the greater part is obtained from the lodes, which are usually worked by quarries and open-cut workings sometimes of a highly dangerous nature. The labourers are to a large extent Chinese and Telegus, with a sparse scattering of Burmese, who do not as a race take kindly to hard work of the kind involved in mining. The ore, when won, is with few exceptions crushed by hand and panned or sluiced. Concentrating machinery is almost unknown, but it will no doubt soon be introduced more generally, for the primitive methods at present in vogue are wasteful and must result in permanent loss, since much of the ore now left in dumps and tailings will for economic reasons be ultimately irrecoverable.

Output.

Table 105 shows the output of wolfram during the period under review. Most of this wolfram was sent to Germany for metallurgical treatment.

[1] *Rec. Geol. Surv. India*, XLIV, p. 26, (1914).

TABLE 105.—*Production of Tungsten-ore during 1909 to 1913.*

—	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Burma—												
Mergui . .	7	*560 (a)*	..	..	103	*8,525*	217·8	*16,963*	205 5	*17,092*	106·66	*8,628*
Tavoy . .	..	..	362	*36,150*	1,165	*88,204*	1,393 4	*93,407*	1,399	*104,809*	863·88	*64,514*
Southern Shan States.	..	..	33	*2,636*	40	*3,260*	60·1	*4,808*	83·7	*5,861*	43·36	*3,313*
Central Provinces—												
Nagpur . .	·2	*19 (b)*	·9	*87*	..	..	·2	*22*	..	..	·26	*26*
TOTAL .	**7·2**	*579*	**395·9**	*38,873*	**1,308**	*99,989*	**1,671·5**	*115,200*	**1,688·2**	*127,762*	**1,014·16**	*76,481*

(a) Estimated at £80 a ton.
(b) Estimated at £4¾ a cwt.

IV.—MINERALS OF GROUP II.

Alum and Bauxite.

Alum.

The separation of sulphate of alumina from decomposed pyritous shales, and the preparation of the double sulphate of alumina and potash, by the introduction of nitre or wood-ashes, was formerly an important industry in a few places, and, on a smaller scale, was practised at numerous places in India. But the importation of cheap alum, principally from the United Kingdom, and its wide distribution by the gradually extending system of railways, have now nearly killed the native industry. Table 107 shows that during the six years 1908-09 to 1913-14 the consumption of foreign alum in India has averaged 73,626 cwts. as compared with an average annual consumption of 65,507 cwts. during the preceding five years.

TABLE 107.—*Consumption of Foreign Aluminous Sulphates (including Alum) in India.*

YEAR.	IMPORTS.		Re-exports.	**Consumption of foreign alum.**
	Quantity.	*Value.*		
	Cwts.	£	Cwts.	**Cwts.**
1908-09	69,618	*21,355*	2,248	**67,370**
1909-10	70,860	*21,776*	2,887	**67,973**
1910-11	71,253	*21,703*	2,242	**69,011**
1911-12	54,529	*16,950*	2,543	**51,986**
1912-13	101,088	*31,146*	2,714	**98,374**
1913-14	90,079	*28,155*	3,037	**87,042**
Average .	*76,238*	*23,514*	*2,612*	**73,626**

The only portion of India for which returns have hitherto been available is the Mianwali district, Punjab, where, during the five years under review, there was an average annual production of 6,035 cwts. valued at £2,812 (see table 108). But for the years 1909 to 1913 figures have been received from Cutch, where there

still languishes an ancient alum industry that was formerly much more extensive[1] :—

	Quantity.	*Value.*
	Cwts.	£
1910	159	*13*
1911	319	*27*
1912	36	*2*
1913	195	*16*

In the Punjab the raw material is a pyritous shale of Eocene age found at Kalabagh, Kotki, and other localities in the Isakhel tahsil. The average sulphur-content in the workable patches of these shales is, according to Mr. N. D. Daru,[2] 9·5 per cent. After roasting, the shale is lixiviated and concentrated. A mixture of crude chlorides, nitrates, and sulphates of sodium (chiefly) and potassium is then added, the alum crystallised out, and then fused in its water of crystallisation and allowed to recrystallise. The product is mainly soda-alum, and is used at Delhi, Hissar, Sirsa, and other centres of the tanning and dyeing industries. The alkaline salts used are obtained by concentrating and crystallising the product of lixiviation of the scrapings of the soil of various localities in the Mianwali and Shahpur districts. Pyritous shale, suited for the manufacture of alum, is also known at Dandot Colliery in the Salt Range. The pyritous shale treated at Madh in Cutch is also of Eocene age.

Alunite.

Alunite, a sulphate of aluminium, is found associated with sulphur in veins traversing Siwalik clays in the Sanni sulphur mines in Khelat, Baluchistan.[3]

TABLE 108.—*Production of Alum in Mianwali District, Punjab, during the years 1909 to 1913.*

YEAR.	Quantity.	*Value.*
	Cwts.	£
1909	4,629	*1,995*
1910	6,220	*2,869*
1911	6,160	*2,792*
1912	5,520	*2,625*
1913	7,647	*3,778*
Average .	*6,035*	*2,812*

[1] Ball's 'Economic Geology,' p. 432, (1881).
[2] *Rec. Geol. Surv. Ind.*, XXXVIII, p. 32, (1909); XL, pp. 265—282, (1910).
[3] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 214, (1909).

Bauxite.

Some years ago it was discovered that many of the lateritic deposits of India are highly aluminous, such aluminous varieties being identical with the substance known as bauxite. Field-work carried out since 1903 by the officers of the Geological Survey has revealed the existence of extensive deposits of this mineral substance in various parts of India, and chemical investigation in the Geological Survey Laboratory and at the Imperial Institute has shown that certain of the Indian bauxites compare very favourably with the Irish, French, and American bauxites placed on the English market.

The richest areas yet discovered in India are the Baihir plateau in the Balaghat district and the neighbourhood of Katni in the Jubbulpore district, both in the Central Provinces. But valuable ores have also been found in Kalahandi State and Chota Nagpur, Bihar and Orissa, in Bhopal and Rewah States, Central India, in the Satara district, Bombay, and in various parts of the Madras Presidency. The bauxites to which the most attention has been up to the present devoted are those of Balaghat and Jubbulpore. Eight analyses of specimens and samples of the Balaghat bauxites have given results ranging between the following limits :—

Alumina, Al_2O_3	51·62 to 58·83
Ferric oxide, Fe_2O_3	2·70 to 10·58
Titanic oxide, TiO_2	6·22 to 13·76
Silica, SiO_2	0·05 to 2·65
Combined water, H_2O	22·76 to 30·72
Moisture	0·40 to 1·14

corresponding to 71·2 to 80·8 per cent. of Al_2O_3 after calcination. With these may be compared the following figures showing the range of analysis of some Irish, French, and American bauxites of commerce analysed at the Imperial Institute :—

Al_2O_3	42 to 63
Fe_2O_3	2 to 21
TiO_2	2 to 6
SiO_2	3 to 13
H_2O	12 to 28
Moisture	5 to 16

Two Katni bauxites gave the following analyses :—

	No. 1.	No. 2.
Al_2O_3	65·48	52·67
Fe_2O_3	3·77	7·04
TiO_2	11·61	7·51
SiO_2	0·38	1·26
H_2O	19·38	29·83

From these figures it will be seen that the Balaghat and Jubbulpore bauxites are of very high grade. There seems also to be little doubt that large quantities of the mineral are available, and the commercial feasibility of making use of these deposits has consequently been under investigation for some years. There are three ways in which the Indian bauxites might be developed :--

(1) Simple export of the raw or calcined material to Europe or America for use in the alumina factories.

(2) Manufacture of pure alumina locally by extraction with alkali, and export of the pure oxide to European or American aluminium works.

(3) Manufacture of the metal in India.

The first proposal is impracticable on account of the low prices of raw bauxite at European ports (22*s.* to 23*s.* per ton is an ordinary price), whilst the third would involve a heavy capital outlay under untried conditions, and an elaborate preliminary investigation before power works could be erected. The second proposal involves much smaller risks, and it has been found on investigation that there are no technical difficulties in the way of manufacturing alumina from Indian bauxites[1]; and in this connection it is of interest to note that the price obtained for manufactured alumina in England has varied from £5-10-0 to £7-10-0 of recent years. Several concessions have been taken out for working the bauxites of the Central Provinces, in the practical investigation of which considerable gress has been made.

The Katni bauxites.

The occurrence of aluminous laterite at Tikari near Katni, Jubbulpore district, was first noted by Mr. F. R. Mallet in 1883.[2] Early in 1905, after the Geological Survey had drawn attention to the identity of aluminous laterites with bauxite, Mr. P. C. Dutt of Jubbulpore secured an exploring license over this area, and later prospecting licenses were taken out by Mr. Dutt and a syndicate formed by him called the Bombay Mining and Prospecting Syndicate, with Messrs. C. Macdonald & Co., of Bombay, as Managing Agents. The objects of this syndicate were varied, including the manufacture of hydrated alumina, alum, and aluminium ; of cement and lime ; and of pottery, fire-bricks, etc. : materials for all these purposes being found within the bauxite concessions.

[1] *Rec. Geol. Surv. Ind.*, XXXV, p. 29 ; XXXVI, p. 220.
[2] *Rec. Geol. Surv. Ind.*, XVI, p. 113.

In August 1912 the Katni Cement and Industrial Company, Ltd., was floated to acquire the Katni properties of the above syndicate, including the bauxite deposits. The cement works commenced operations in December 1914 with satisfactory results. Works have also been erected at Katni for the manufacture of tiles, piping, fire-bricks, and bauxite bricks.

Meanwhile Mr. P. C. Dutt has acquired other bauxite deposits near Katni, and also near Dundi Station, East Indian Railway, also in the Jubbulpore district, and has continued his efforts to enlist the help of capital to work both his Jubbulpore and Balaghat bauxite deposits for the manufacture of alumina and ultimately of aluminium. The invention of the Serpek process appears to have increased the possibility of establishing such an industry in India. In this process a mixture of bauxite and coal is heated in an electric furnace with production of aluminium nitride. The nitride is treated with a solution of caustic soda with formation of sodium aluminate and ammonia : the alumina is extracted from the aluminate in the ordinary way and the ammonia is converted into the valuable manure, ammonium sulphate. The investigations of Mr. Dutt and his friends have led, during the period under review, to the following production of bauxite, a small portion of which has been exported to Europe for various tests :—

	Quantity.	*Value.*
	Tons.	£
1909	32	*12*
1910	66	*25*
1911	12	*5*
1912	950	*516*
1913	1,184	*33*

The extent of the demand for aluminium in India may be gauged from the following import figures for the two years 1912-13 and 1913-14, the only ones for which statistics are available :—

	Tons.	£
1912-13	1,795	170,097
1913-14	1,317	142,528

On the subject of Indian bauxites, the following references may be consulted :—

(1) T. H. Holland, *Geol. Mag.*, Dec. IV, Vol. X, pp. 59—69, (1903).

(2) T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXII, pp. 95, 141—144, (1905).

(3) J. M. Maclaren, *Geol. Mag.*, Dec. V, Vol. III, pp. 536—547, (1906).

(4) T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXV, pp. 28—30, (1907).

(5) W. R. Dunstan, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 213—220, (1908).

(6) L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 374—380, (1909).

(7) L. L. Fermor, R. C. Burton, and M. Vinayak Rao, *Rec. Geol. Surv. Ind.*, XLV, pp. 111—112, (1915).

Amber.

Production.

The production of amber during the five years 1909 to 1913 is shown in table 109. The average annual production was 29 cwts. valued at £6·3 per cwt. compared with 104 cwts. valued at £6·2 per cwt. during the five years 1904 to 1908. The decreased production of amber is attributed partly to troubles in China with a resultant decreased demand and partly to the rival attractions of rubber plantations and jadeite mining. The right to collect a 5 per cent. *ad valorem* royalty on amber in the Myitkyina and Upper Chindwin districts is farmed out with the jadeite royalties (see page 125).

TABLE 109.—*Production of Amber in the Myitkyina District, Upper Burma.*

YEAR.	Quantity.	*Value.*
	Cwts.	£
1909	31	*287*
1910	63	*283*
1911	14	*133*
1912	27	*179*
1913	10	*29*
Average	*29*	*182*

Occurrence.

The Burmese diggings for amber are situated in the Hukong valley in the Nangotaimaw hills near Lalaung village in about lat. 26° 10′ and long. 96°. The substance is found in clays of probable Miocene age, and fragments of amber have been similarly found in association with beds of this age in other parts of Burma, for example, at Mantha in the Shwebo district, and on the oil-field of Yenangyat in the Pakokku district. Most of the material is brought from the Hukong valley in Upper Burma to Mandalay, where beads for rosaries, *nadaungs* (ear-cylinders), and other trinkets for personal ornament are made from the transparent varieties.

Chemical and physical properties.

The amber of Burma differs in chemical and physical characters from previously known varieties and the name *burmite* has been consequently suggested for it as a specific distinction.[1] The well-known amber of Eastern Prussia contains from 2½ to 6 per cent. of succinic acid and is consequently known to the mineralogist as *succinite*, but the Burmese amber contains no succinic acid, though the products of its dry distillation include formic acid and pyrogallol. Its ultimate chemical composition has been determined to be as follows:—

Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
	100·00

The specific gravity of burmite varies between 1·030 and 1·095. It is distinguished from many other amber-like resins by its superior hardness and greater toughness, which render it fit for carving and turning. It possesses a peculiar fluorescence, like that which distinguishes the Sicilian variety simetite.

Apart from the occurrence of a large percentage of discoloured and opaque pieces, many of the large fragments obtained are damaged

[1] O. Helm, *Rec. Geol. Surv. Ind.*, XXV, p. 180, (1892), and XXVI, p. 61, (1893).

by cracks filled in with calcite; but otherwise there appears to be a large quantity of material which might be put on the market with profit.

Antimony.

A mining lease to work the well-known antimony-ores (stibnite with oxides) near the Shigri glacier in Lahaul was granted in 1904 to Colonel R. H. F. Rennick. The stibnite lodes are situated at an elevation of 13,500 feet, and are associated with gneissose granite. To reach the locality it is necessary to cross the Hamta Pass (14,500 feet), work is possible for two or three months only every year, and labour and supplies have to be brought from the nearest village, 3½ marches away. In spite of these difficulties, however, Colonel Rennick succeeded in 1905 in shipping over 400 maunds (15 tons) of stibnite to England. Since then he has quarried a like quantity and thinks his deposits extensive enough to yield 200 to 400 maunds of stibnite a year, but no further shipments have been made on account of the low price of star regulus. The stibnite has yielded 6 cwts. of gold per ton. Galena and blende are also found in the same locality, the former being argentiferous.

The existence of an antimony deposit of considerable size in the Möng Hsu State, one of the Southern Shan States, is indicated by the return amongst the mineral statistics for Burma for 1908 of an output, under a mining lease held by Mr. W. R. Hillier of Lashio, of 1,000 tons of antimony-ore, of which 11 tons were sent to London for assay and valuation. The output from the Southern Shan States in the following year was recorded as 2½ tons and since then there have been no returns. No information is available concerning this occurrence.

In 1905, stibnite with cervantite was found in the Northern Shan States,[1] whilst the lead slags at Shekran in Jhalawan, Baluchistan, are antimonial.[2] The tetrahedrite found in the Sleemanabad copper lodes [3] is also highly antimonial. A few pounds of antimony-ore are recorded from the Jhelum district, Punjab, for the years 1911 to 1913.

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234, (1906).
[2] G. H. Tipper, *ibid.*, XXXV, p. 51, (1907).
[3] L. L. Fermor, *ibid.*, XXXIII, p. 62, (1906).

Arsenic.

Occurrence.

The chief indigenous source of arsenic is the orpiment mines of Chitral, where the mineral is exploited by the Mehtar of Chitral. The output of these, however, has latterly fallen off considerably, being under 10 tons in 1905-06; and no returns are available for recent years, although the industry is still carried on. The occurrence of orpiment near Munsiari in Kumaon has long been known,[1] small quantities of this mineral and of realgar, the other sulphide, being sold in the bazaars of Northern India; but it was not till 1906, when Messrs. G. deP. Cotter and J. Coggin Brown found scattered fragments of both minerals lying on the moraine material of the Shankalpa glacier, that any precise locality was ascertained. The ore was not found *in situ*, but had probably come from the hill face immediately above.[2] Large lumps of leucopyrite, an arsenide of iron, have been found in the pegmatites of the mica-mining field near Gawan in Hazaribagh district,[3] and other arsenides have been found associated with pyritous lodes in various places, but no attempt has been made to recover arsenic from these occurrences. Two species of arsenates have been found in India: one (tilasite) in the Kajlidongri manganese mine, Jhabua State, Central India; and the other (fermorite) in the Sitapar manganese mine, Chindwara district, Central Provinces [4]; but they have not proved to be of economic importance.

Exports and imports.

Details with regard to the production and use of Indian arsenic are not available, but there has been a considerable trade in both Indian and foreign arsenic, presumably in the form of white arsenic.

Table 110 shows the extent of this trade for the period under review, but does not include the trade in orpiment, which is shown separately. By comparison with the corresponding tables of the two previous reviews it will be seen that the annual imports of foreign arsenic have remained remarkably constant for some years (2,346 tons for 1898-1903; 2,370 tons for 1904-08), indicating a very steady consumption.

[1] A. W. Lawder, *Rec. Geol. Surv. Ind.*, II, p. 88, (1869).
[2] *Ibid*, XXXVI, p. 129, (1908).
[3] T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 51, (1902).
[4] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 218—219, (1909); and G. F. Herbert Smith and G. T. Prior, *Mineralogical Mag.*, XVI, pp. 84—96, (1911).

TABLE 110.—*Average Annual Exports and Imports of Arsenic for the years 1908-09 to 1913-14.*

—	Quantity.	Value.
	Cwts.	
Exports of Indian Arsenic—		
To Straits Settlements	135	
„ Other Countries	21	
TOTAL	**156**	**£271**
Imports of Foreign Arsenic—		
From United Kingdom	252	
„ Germany	490	
„ Belgium	283	
„ China (with Hongkong)	1,209	
„ Straits Settlements	95	
„ Other Countries	267	
TOTAL	**2,596**	**£3,680**
Re-export of Foreign Arsenic	*34*	*£62*

Chinese orpiment.

Orpiment, the yellow sulphide of arsenic, is largely imported into Burma from Western China for use mainly as a pigment. During the five years 1908-09 to 1912-13 the average annual imports across this frontier amounted to 7,150 cwts. valued at £8,932 or 25 shillings per cwt. (see table 111) as compared with 6,701 cwts. valued at £8,130 or 24 shillings per cwt. during the five years 1903-04 to 1907-08, and 9,551 cwts. valued at £11,470 or 24¼ shillings per cwt. during the six years 1897-98 to 1902-03.

The mineral is used as a pigment in the manufacture of Indian ornamental lac-wares and the Burmese lacquer-work, in which the favourite greens of the Pagan workers are produced by mixtures of indigo and orpiment, and the so-called gold-lacquer of Prome by

powdered orpiment and gum. It is used also for the designs on the Afridi wax-cloths.

TABLE 111.—*Imports of Orpiment from Western China.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1908-09	8,913	*10,940*	24·55
1909-10	7,929	*9,732*	24·54
1910-11	9,439	*11,740*	24·87
1911-12	5,430	*7,061*	26·01
1912-13	4,041	*5,189*	25·68
1913-14	4,377	*5,324*	24·33
Average	6,688	*8,331*	*24·91*

Asbestos.

Attempts to develop asbestos in India have not yet met with any success on account of the inferior quality of the material in the deposits hitherto discovered. In 1910, 3 tons of asbestos valued at £6 were extracted in the Bhandara district, Central Provinces, presumably during prospecting operations, whilst in 1913 a small amount of work was carried out in the Hassan district, Mysore. In addition to the deposits referred to in the previous review several fresh occurrences were discovered during the period 1909-1913, of which two appeared to be of some size. One of these, near Dev Mori in Idar State, Bombay Presidency,[1] contains a considerable amount of amphibole-asbestos in large rod-like masses yielding long-staple asbestos up to 8 inches; but unfortunately the product has proved to be too brittle. The other occurrence is in the Seraikela State, Singhbhum, the asbestos being of the chrysotile variety, obtainable in long columnar masses suffering from the same defect of brittleness.

[1] C. S. Middlemiss, *Rec. Geol. Surv. Ind.*, XLII, pp. 53, 73, (1912).

Barytes.

Barytes, or heavy-spar, has many applications in the arts, such as giving weight to paper, adulterating white lead, and as a flux in metallurgy (particularly for ferro-manganese). It seems to be widely distributed throughout the Indian Empire, but, with one exception, has not, as far as we know, been turned to account. At Sleemanabad in the Jubbulpore district, one of the copper lodes is rich in barytes.[1] A wagon-load (about 16 tons) of this was despatched to Calcutta about the year 1904 for use in the works of the Shalimar Paint, Colour and Varnish Company, Ltd. The quality was found to be poor, and a nominal value assigned to it of Rs. 7 per ton.

Amongst other known occurrences of barytes in India, the following may be mentioned:—

(1) Narravada, Nellore district, Madras: barytes veins in mica schist, into which they pass in places.[2]

(2) Bawdwin silver-lead mines, Northern Shan States: in considerable quantity at one spot.[3]

(3) Taung-gaung, Mandalay district, Burma: a bed of barytes 6 to 7 feet thick.[4]

(4) Khelat and Las Bela States, Baluchistan: fairly abundant in the Belemnite shales; the most accessible locality is Pabni Chauki, about two days' march from Karachi.[5] Barytes has also been found in the Middle Khirthar shales.

(5) Alangayam, Salem district, Madras, where certain gneisses are traversed by a plexus of quartz-barytes veins.[6]

(6) Balpalpalle, and other localities near Betamcharla, Karnul district, Madras: several tons of barytes have been sent to Shalimar.[7]

Borax.

No undoubted occurrence of borax is known within British Indian territory, and the material exported, which during the last five

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 62, (1906).
[2] H. C. Jones, *ibid.*, XXXVI, p. 233, (1908).
[3] T. D. LaTouche and J. C. Brown, *ibid.*, XXXVII, p. 255, (1909).
[4] H. H. Hayden, MS. notes, (1896).
[5] G. H. Tipper, *ibid.*, XXXVIII, p. 214, (1909).
[6] T. H. Holland, *ibid.*, XXX, p. 236, (1897).
[7] According to information supplied by Mr. A. Ghose.

years has averaged annually 4,386 cwts. of a value of £5,530 (table 112), is practically all obtained from Tibet and Ladakh, being imported across the frontier into the Punjab and United Provinces. The word *tincal* by which it is known in the bazaars is possibly a corruption of the Tibetan name for borax, and is in common use on the Punjab frontier, where one meets, in the Himalayan passes, herds of goats and sheep coming down in the spring from Tibet, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

TABLE 112.—*Exports of Borax by Sea from India during the years 1908-09 to 1913-14.*

Year.	Quantity.		Value.	Value per cwt.
	Cwts.	*Metric Tons.*		
			£	Shillings.
1908-09	2,741	*139*	3,498	25·52
1909-10	5,976	*304*	7,479	25·03
1910-11	5,232	*266*	6,068	23·26
1911-12	3,326	*169*	3,527	21·20
1912-13	4,770	*242*	7,457	31·26
1913-14	4,270	*217*	5,131	24·03
Average	*4,386*	*223*	*5,527*	*25·22*

In addition to the borax sent by sea to foreign countries, small quantities cross the frontier into Nepal, Kashmir, Khelat, Afghanistan, Tibet, and China. During the six years, 1908-09 to 1913-14, these trans-frontier exports of borax have averaged 9 cwts. a year with an average total value of Rs. 169 (£91) or Rs. 18·8 (24*s.*) per cwt. The export trade has very seriously declined. Twenty-five years ago the borax sent out of India amounted to over 16,000 cwts. a year, valued at £24,000. At that time the principal part of the material exported went to the United Kingdom (14,134 cwts. in

1883-84), but with the discovery of large deposits of calcium borate in America the demand for borax from India ceased, and now the only large customers are the Straits Settlements and China, the latter having taken 3,610 cwts., and the former 637 cwts., of the average annual total of 4,386 cwts. exported.

The amount of borax imported into India across the frontier has averaged (as shown in table 113) 20,885 cwts. of the value of £20,885, as compared with an average annual figure of 19,946 cwts. valued at £16,336 for the period of the previous review; whilst the amount (presumably refined borax) imported by sea has averaged (as shown in table 114) 5,325 cwts., of the value of £5,044, as compared with 2,436 cwts., of the value of £1,572, during the period 1904 to 1908, and an average annual figure of 257 cwts. worth £261 for the earlier period 1898-1903. Adding the land and sea imports, it is seen that instead of the very slight decrease recorded in the previous review (page 220) there has been a substantial increase in the consumption of borax in India from 17,341 cwts. per annum during the period 1903-04 to 1907-08 to 21,825 cwts. per annum during the period 1908-09 to 1913-14.

TABLE 113.—*Imports of Borax by Land during the years 1908-09 to 1913-14.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1908-09	23,108	*18,511*	16·02
1909-10	28,825	*25,724*	17·84
1910-11	23,143	*32,950*	28·47
1911-12	21,975	*31,747*	28·89
1912-13	13,832	*7,514*	10·86
1913-14	14,427	*9,401*	13·08
Average .	*20,885*	*20,974*	*20·08*

TABLE 114.—*Imports of Borax by Sea during the years 1908-09 to 1913-14.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1908-09	3,564	*3,355*	18·82
1909-10	6,546	*5,950*	18·87
1910-11	4,084	*3,920*	19·19
1911-12	5,813	*5,334*	18·35
1912-13	6,688	*6,144*	18·37
1913-14	5,255	*5,559*	21·15
Average	*5,325*	*5,044*	*18·94*

Of the amounts brought across the frontier, and shown in table 113 to have an annual average of 20,885 cwts., 414 cwts., or 2·0 per cent., came from Ladakh and Central Asia, whilst 20,471 cwts., or 98·0 per cent., came from Chinese Tibet.

Of the amounts imported by sea, and shown in table 114 to have an annual average of 5,325 cwts., 4,977 cwts., or 93·5 per cent., came from the United Kingdom, 274 cwts., or 5·1 per cent., came from Germany, and the remainder from other countries.

The borax obtained in the Puga valley of Ladakh, Kashmir, is deposited from hot springs associated with sulphur deposits, which probably represent the final phase of declining volcanic action. The material collected in Tibet is obtained from salt lakes, which have possibly obtained their borax in a similar way from hypogene sources. In other parts of the world, as in California, Argentina, Bolivia, and Chile, deposits of calcium borate, colemanite, are worked for their boracic acid, besides the borax of salt lakes and marsh deposits. In Italy borax is obtained from volcanic fumaroles.

Building Materials.

If the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country. The attempt made to obtain returns of building stones, road metal, and clays used in India was abandoned when it was shown, in 1899, that the returns could not possibly rank in value much above mere guesses.

In the absence of statistics, it is difficult to express shortly the trade in a material so widespread as common building stone. There are, however, a few features which are specially developed in, if not peculiar to, India. In the southern part of the Peninsula, various igneous rocks—the charnockite series near Madras, and the gneissose granites of North Arcot and Mysore—are largely used; in the centre, slates and limestones from the Cuddapah series, and basalt from the Deccan trap-flows are quarried. In Central India, the Central and United Provinces, the great Vindhyan system provides incomparable sandstones and limestones, while in Bengal and the Central Provinces the Gondwana sandstones are used on and near the coalfields. In the Narbada valley the so-called coralline limestone of the Bagh series forms an excellent building stone with a certain claim to inclusion in the ornamental class. Among the younger rocks the nummulitic limestones in the north-west and in Assam are largely quarried, while the foraminiferal Porbandar stone in Kathiawar is extensively used in Bombay and Karachi.[1]

The abundant development of concretionary carbonate of lime in the great alluvial plains, and the extensive development of laterite on the Peninsula and in Burma are dependent, in their more pronounced forms, on conditions peculiar to tropical climates, and these two substances, the so-called *kankar* and laterite, are about the most valuable assets in building material possessed by the country.

The three great physical divisions of India, being the result of three distinct geological histories, show general contrasts in the materials available for simple as well as ornamental building purposes. In the great alluvial plains buildings of importance are usually made of brick, but the surrounding tracts furnish a supply of stone, which is steadily increasing with improved facilities for transport. The monotonous line of brick and stucco buildings in Calcutta is being relieved by the introduction of Vindhyan sandstones from Mirzapur and the calcareous freestones and buff traps brought from the western coast. But the use of Italian marbles, mainly for floorings and, in a smaller way, the introduction of polished granite

Imports.

[1] A 'Memoir on the Economic Geology of Navanagar State' by G. E. Howard Adye, (1914), deals with the economic uses of the miliolite limestones, Deccan Trap rocks, both acid and basic, and the laterite of this State.

columns and blocks from Aberdeen and Peterhead, have continued, mainly because these materials, which are no better than, and possibly on the whole inferior to, those of Indian origin, are placed on the market at cheap rates and in a manner suitable to the immediate requirements of the builder and architect.

During the six years 1908-09 to 1913-14 the value of building and engineering materials imported from foreign countries into India has had an average annual value of £560,735, exclusive of stone and marble, which have averaged £28,569 annually during the same period. The substances included in the trade statistics under the heading of building materials and entered into the above total comprise asphalt, bricks and tiles, cement, chalk and lime, clay and earthenware piping. The values of some of these are given in the section on clays. The quantity of cement imported annually, during the six years 1908-09 to 1913-14, has averaged 144,425 tons valued at £384,073; and the annual imports of chalk and lime during the same period have averaged 2,175 tons valued at £3,652.

Ornamental building stone.

It is naturally surprising to find that a country which owes its reputation for architectural monuments as much to the fact that it possesses an unlimited supply of ornamental building stone as to the genius of its people is dependent on foreign supplies to the extent indicated by these import returns. It can hardly be an accident that each dynasty which has existed in India since the wonderful Buddhist topes of Sanchi and Bharhut were erected has been marked by the erection of great monuments in stone, and there can be little doubt that the abundance of suitable material has been an important contributory cause in the growth of India's reputation for architecture.

Besides the architectural remains left by the Buddhists, there are famous works in stone by the Hindus of the eight to tenth centuries, including the great Dravidian temples of Southern India, mostly built of granites and other crystalline rocks, and the richly ornamented buildings of Orissa and of Chanda built of Gondwana sandstones. The Pathans and Moghals utilised both the Vindhyan sandstones of Central India and the beds of marble in Rajputana for building their magnificent mosques, palaces and tombs in the cities of Northern India. It is only necessary to mention here Akbar's city of Fatehpur Sikri, where the red and mottled sandstone of the Bhander series was used, and the famous Taj, built

mainly of white Makrana marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and blood-stones from the Deccan trap, and red jasper from the Gwalior (Bijawar) series.

The delicate and intricate carvings, for which some varieties of the Indian sandstone are so well suited, are admirably shown in an 'Illustrated Catalogue of Ornamental Carved Stone in Gwalior,' published by the Department of Commerce and Industry, Gwalior, in 1912.

Although, in most cases, reliable statistics concerning the production of building stones in India are not obtainable, yet we give here such figures as are available, excluding those relating to marble and slate, which are treated in separate sections.

Granite and gneiss.

Gneissose granites and gneisses are used as building stones and for road-metal in many parts of Peninsular India, particularly in the Madras Presidency, for which returns have been available since 1910. Figures of production and value for Bihar and Orissa, Burma, and Madras are given in table 115.

The end of the previous quinquennial period saw a sudden increase in the Burmese production of granite and gneiss, from 27,781 tons in 1907 to 340,939 tons in 1908. This was largely due to the development of quarries in gneissose granite in the Thatôn district for the supply of stone to the Burma Railways Company and the Town Lands Reclamation Works in Rangoon. Owing probably to the same causes the production of the Thatôn quarries reached the enormous figure of 7,642,268 tons in 1909, valued at £344,704.[1] Since then the production from this district has been relatively small, but in 1909 quarrying began at Kalagauk island in the Amherst district in connection with the Rangoon River Training scheme. The output in 1909 was 57,500 tons which, with the introduction of a regular service of hopper barges, reached a total of 295,125 tons in 1912. With the completion of the scheme the works were closed down in 1914. During the same period there has been a considerable output from the Chingleput district, accounting for a large part of the total for the Madras Presidency, and largely intended presumably, for use as road metal in the town of Madras.

[1] On enquiry we find that this figure must be accepted with reserve, as the Government of Burma is unable to confirm it, because the district records have been destroyed.

TABLE 115.—*Production of Granite and Gneiss during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons	£	Tons	£	Tons.	£	Tons.	£
Bihar and Orissa	..	..	3,235	*220*	2,708	*395*	9,374	*2,044*	15,587	*2,331*	6,181	*998*
Burma . .	7,733,855	*465,855*	145,728	*15,481*	380,144	*39,807*	343,008	*32,230*	317,236	*36,879*	1,783,994	*118,650*
Madras . .	(a) 20,224	*4,045*	114,897	*1,248*	85,402	*1,951*	91,458	*3,938*	62,001	*2,332*	74,796	*2,703*
TOTAL .	**7,754,079**	*469,900*	**263,860**	*19,949*	**468,254**	*42,153*	**443,840**	*38,212*	**394,824**	*41,542*	**1,864,971**	*122,351*

(a) Figures relate to Coorg.

Sandstone.

The available figures for the production of sandstone in India are shown in table 116. Those shown for the United Provinces refer to the output of Upper Vindhyan sandstone from the quarries at Chunar in the Mirzapur district, which has averaged 163,864 tons a year, valued at £22,029, and those for Bihar and Orissa chiefly to the output of Vindhyan and Gondwana sandstones, from the districts of Shahabad and Manbhum respectively. In Burma, sandstone is quarried in many districts, amongst which may be mentioned the Northern Shan States, Meiktila, Thaton, Minbu, Kyaukse, Pakokku, Amherst, Shwebo, and Akyab.

TABLE 116.—*Production of Sandstone during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons	£
Bihar and Orissa	..	..	82,906	*12,482*	46,955	*8,498*	30,527	*7,532*	26,422	*2,211*	37,380	*6,145*
Burma . .	316,812	*9,478*	97,096	*7,564*	116,699	*10,273*	120,582	*7,163*	76,497	*4,992*	145,537	*7,894*
Hyderabad .	..	..	(*a*)	*11*	(*a*)	*2*	..	..	..	..	(*a*)	*3*
Punjab . .	..	..	..	..	..	..	35,747	*2,519*	143,019	*12,772*	35,753	*3,058*
Rajputana .	255	*30*	262	*30*	308	*36*	..	..	17,861	*360*	3,737	*91*
United Provinces .	154,945	*17,881*	181,174	*20,070*	135,096	*20,085*	193,905	*22,222*	154,197	*29,887*	163,864	*22,029*
TOTAL .	**472,012**	*27,389*	**361,528**	*40,157*	**299,058**	*38,894*	**380,761**	*39,436*	**417,996**	*50,222*	**386,271**	*39,220*

(*a*) Not available.

Limestone.

The subject of building materials naturally includes limestone used as a building stone, and the two derived products—lime and cement; these are obtained, obviously, from the most conveniently situated deposits of limestones, such as those of the Upper Vindhyan series worked near Sutna in the Rewah State by the Sutna Stone and Lime Company, Ltd.; those of the Lower Vindhyan series worked at Katni in the Jubbulpore district by Messrs. Cook & Sons and others; those worked in the Cuddapah series at Bisra and Rourkela in Gangpur State by the Bisra Stone Lime Company; or the various bands of crystalline limestones in Madras, Central India, and Rajputana, and the nummulitic limestones of Assam. Such figures as are available for the production of limestone during the period under review are given in table 117. The production of the Sutna Stone and Lime Company in Rewah may be gauged from the quantities despatched from the works during the five years 1909 to 1913.

The quantity of limestone has averaged annually 34,218 tons valued at £2,497; the unslaked lime has averaged 18,695 tons valued at £10,989; the slaked lime has averaged 1,818 tons valued at £383; and the stone setts have averaged 56,283 pieces valued at £283. As is shown by these figures, much of the limestone is not converted to lime; it is instead railed a distance of 530 miles to the Barakar Iron Works, where it is used as a flux in the blast furnaces.

A new company, the Maihar Stone and Lime Company, Ltd., has produced an average annual amount of 15,228 tons of Vindhyan limestone during the three years 1911-13, from quarries in the Maihar State, Central India. There is also a small annual production of limestone in Gwalior State, both kankar and Bhander (Vindhyan) limestone being used.

The production from Bihar and Orissa is derived chiefly from Gangpur State with, in some years, large amounts of kankar and limestone from the Shahabad district. The Gangpur output includes the production of the Bisra Stone Lime Company which has averaged 36,496 tons valued at £2,433 (1 rupee a ton) for the five years 1909 to 1913; but in the years 1912 and 1913 there was also the following production of dolomite from Panposh by the Tata Iron and Steel Company for use as a flux in their works at Sakchi :—

	Tons.
1912	40,465
1913	90,408

valued at rupees 2 per ton.

Towards the end of the quinquennium the opening of the Dehri-Rohtas Light Railway led to the formation of three companies—The Kalianpur Lime Works, Ltd., The Kuchwar Lime and Stone Company, Ltd., and The Sone Stone and Lime Works—to work the Rohtas (Vindhyan) limestone at and near Banjari in the Shahabad district. The lime produced is said to be of good quality, and consequently a considerable increase in the output of limestone in this district may be expected in the near future.

The production shown for the Central Provinces refers, with the exception of a trivial output from the Hoshangabad district, entirely to Katni, where the limestone quarries come under the control of the Indian Mines Act. The quantity raised under this Act has varied from 56,002 tons in 1909 to 92,442 tons in 1911, the average for the quinquennium being 78,240 tons worth £5,198.

The average daily labour employed is shown below separately for each year, the average for the period being 2,959 persons. The number of deaths has been 2, giving an average death-rate of 0·13 per 1,000.

	Persons.
1909	3,709
1910	2,420
1911	3,382
1912	2,606
1913	2,677

A very small proportion of the limestone, shown as quarried in Eastern Bengal and Assam, comes from the Lakhimpur district and Manipur, practically the whole of the output being from the Khasi and Jaintia Hills, where the nummulitic limestone is being worked by the Sylhet Lime Company, Ltd. The output from this province has varied from 79,486 tons in 1912 to 123,110 tons in 1910, the average quantity being 96,402 tons worth £9.219.

As regards the other areas reported as producing limestone, that in Baluchistan comes from the Las Bela State; the limestone of Burma comes from many districts, the most important of which are Mandalay, Kyaukse, Southern Shan States, Northern Shan States, and Meiktila; a large proportion of the Madras production comes from the Cuddapah district. The small production reported from the Punjab comes from the Jhelum, Hoshiarpur and Ambala districts, whilst the output reported from Rajputana comes chiefly from Alwar and Sirohi. The small production reported from the United Provinces comes from the Naini Tal, Almora, Garhwal, and Dehra Dun districts.

Kankar.

One of the most widespread and interesting sources of lime is the material generally known by the name of *kankar*. The commonest mode of occurrence is in the great alluvial deposits, particularly in the older alluvium, in which the calcareous substances have segregated from the rest of the materials and have grown into irregular lumps like flints in chalk, including in the concretions a certain amount of the argillaceous substances, which, when the *kankar* is burnt, is present in a proportion not far removed from that necessary to produce a hydraulic lime.

TABLE 117.—*Production of Limestone and Kankar during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Assam (*a*)	95,973	*6,867*	123,110	*10,866*	102,913	*13,405*	79,486	*7,426*	80,527	*7,532*	96,402	*9,219*
Baluchistan	466	*845*	481	*449*	252	*320*	292	*477*	235	*363*	345	*491*
Bihar and Orissa	42,000	*2,800*	81,362	*20,676*	72,268	*9,209*	72,941	*10.575*	165.716	*43,953*	86,857	*17,443*
Bombay	..	..	300	*100*	400	*133*	..	..	..	..	140	*47*
Burma	104.797	*11,307*	232,960	*15,308*	248,059	*30,301*	223,857	*12.740*	249.084	*9,908*	211,751	*15,913*
Central India (*b*)	56,274	*3,968*	32,745	*2,745*	51,984	*3,785*	54,862	*4,019*	44,444	*3,276*	40,062	*3,558*
Do. (*c*)	31,059	*2,329*	45,846	*3,438*	38,488	*2,887*	35,145	*2,636*	28,661	*2,149*	35,840	*2,688*
Central Provinces	56,002	*3,570*	80,985	*4,731*	97,972	*6,503*	93,664	*6,022*	70,459	*5,481*	79,816	*5,262*
Madras	..	..	59,158	*1,173*	86,618	*1,437*	39,322	*1.352*	58,242	*1,816*	48,668	*1,155*
North-West Frontier Province	..	..	..	..	..	..	3,200	*71*	4,500	*100*	1,540	*34*
Punjab	500	*47*	13,494	*880* (*a*)	8,009	*821*	10,096	*675*	10,824	*652*	8,584	*615*
Rajputana	29,223	*3,540*	13,259	*1,164*	8,714	*157*	801	*478*	800	*478*	10,559	*1,163*
United Provinces	..	..	89	*10*	495	*138*	65	*10*	114	*14*	153	*34*
TOTAL	**416,294**	*35,273*	**683,789**	*61,540*	**716,172**	*69,096*	**613,731**	*46,484*	**713,606**	*75,722*	**628,717**	*57,622*

(*a*) Derived almost entirely from the Khasi and Jaintia Hills with very small quantities from Lakhimpur and Manipur.
(*b*) Production of Maihar, Gwalior, and the Sutna Stone and Lime Company excluding (*c*).
(*c*) Limestone converted to lime before despatch by the Sutna Stone and Lime Company.

Laterite.

The curious superficial rock known as laterite is widely distributed over the whole of the Peninsula of India and in Burma. In certain cases it has a special value as an ore of aluminium (see page 228), iron, or manganese, according to composition (see page 179), but it is also very widely used as road-metal and as a building stone for culverts and buildings; but, in most cases, no statistics are collected. In table 118 are given the statistics for Bihar and Orissa, Burma, and Madras. The figures for Bihar and Orissa relate entirely to the Puri district. The annual Burmese output during the period averages 228,590 tons valued at £22,594, giving an average value of 2*s.* 0*d.* (Re. 1-8) per ton. The output comes from some twenty districts, but by far the most important are Hanthawaddy[1] (and Insein), with an average annual output during the period of 128,000 tons, Thaton, Bassein, Prome, Tavoy, and Amherst, all of which lie either on the coast or in the Irrawaddy valley. The laterite of Madras comes from 8 coastal districts, of which Chingleput (average of 52,000 for years 1910-13) and Malabar (24,000 tons, 1910-13) contribute by far the larger portion.

TABLE 118.—*Production of Laterite during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa .	..	..	14,901	*1,863*	17,493	*2,187*	15,186	*1,898*	4,171	*56*	10,350	*1,201*
Burma . .	302,938	*20,993*	251,383	*20,743*	212,467	*25,527*	178,098	*29,269*	198,062	*16,440*	228,590	*22,594*
Madras . .	119	*8*	117,536	*2,049*	107,484	*1,654*	68,981	*2,199*	90,752	*3,489*	76,374	*1,880*
TOTAL .	**303,057**	*21,001*	**383,820**	*24,655*	**337,444**	*29,368*	**262,265**	*33,366*	**292,985**	*19,985*	**315,914**	*25,675*

[1] The district was subdivided during the period.

Gravel.

The mineral returns of Burma regularly give details of the production of gravel in various districts; the total figures are—

1909	119,087 tons	valued at	8,590
1910	101,380 „	„ „	5,172
1911	91,554 „	„ „	5,135
1912	112,093 „	„ „	4,931
1913	102,622 „	„ „	2,886
Average	*105,347*		*5,343*

The most important districts are Henzada, Mandalay, Lower Chindwin, and Tavoy. The material is used for the repair of roads.

Clays.

Importance of clay as a mineral product.

The important part played by clay in the industrial development of a country is not generally recognised, but can easily be illustrated by reference to the mineral statistics of two such industrially advanced countries as the United Kingdom and the United States, for which see table 2 on page 12. From this it is seen that in 1912 clay ranked fourth in value amongst the mineral products of each country. The output for the United Kingdom in that year was 12,808,950 statute tons valued at £1,633,736. The figures for the United States relate not to the raw material, but to the products manufactured therefrom, and the magnitude of the total value—£35,484,861—can be grasped when it is pointed out that this is nearly four times the value of the total Indian mineral output for the same year of all minerals for which statistics are available.

TABLE 119.—*Production of Clay in India during 1909 to 1913.*

PROVINCE.	1909.		1910.		1911		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons	£	Tons.	£	Tons.	£	Tons.	£
Bengal	..	..	22,823	*1,064*	24,409	*1,172*	19,103	*951*	19,054	*953*	17,078	*828*
Bihar and Orissa	..	..	9	*2*	17	*3*	33	*7*	1,091(*a*)	*19*	230	*6*
Burma	1,123,347	*39,322*	490,063	*20,316*	710,705	*23,244*	574,618	*21,765*	833(*b*)	*165*	579,913	*20,962*
Central India	..	..	18	*6*	21	*6*	..	..	..	..	8	*2*
Central Provinces	10,214	*319*	15,752	*733*	15,400	*702*	20,062	*847*	25,482	*984*	17,382	*717*
Delhi	..	..	..	..	..	..	..	..	962	*623*	192	*125*
Madras	.	..	119,916	*2,641*	223,304	*6,720*	200,424	*8,257*	(*b*)	.	108,729	*3,524*
United Provinces	..	..	71	*10*	2	..	.	..	..	..	14	*2*
TOTAL	**1,133,561**	*39,641*	**648,652**	*24,772*	**973,858**	*31,847*	**814,240**	*31,827*	**47,422**	*2,744*	**723,546**	*26,166*

(*a*) This includes 1,000 tons of kaolin from Bhagalpur District, the value of which has not been reported, as the material could not be sold owing to its being mixed with granite.

(*b*) The Government of India, Department of Commerce and Industry, in their Circular No 7358-7369—121, dated the 8th September 1913, informed all the Local Governments that information on ordinary clay or kankar need not be included in their annual mineral returns and hence their decrease in, and total absence of, figures in this head from Burma and Madras respectively.

Production in India.

No statistics approaching any degree of completeness are obtainable to show the extent of the undoubtedly great industrial value of the clays in India. They include the common clays used all over the country for the manufacture of bricks, tiles and the cheaper forms of pottery; finer varieties used for glazed pottery, which in places has obtained a reputation for artistic merit; fire-clays raised in considerable quantities on some of the Gondwana coal-fields; and fuller's earth, which is mined in the Central Provinces and in Rajputana.

For Burma fairly complete returns are available up to 1912, stated separately for each district, the most important districts being Yamethin, Myingyan, Henzada, Ma-ubin, Pyapon and Hanthawaddy. The output for the four years 1909-12 is summarised in table 119, from which it will be seen that the average annual output has been 724,683 tons valued at Rs. 3,92,424 or £26,162, giving an average value of 8·7 annas or pence per ton. These clays are common brick and potter's clays.

The Bengal output is derived from the Burdwan district. That of the Central Provinces is mainly from the Jubbulpore district with a small production from the Hoshangabad district. The main portion of the Jubbulpore output is derived from quarries in the Upper Gondwanas near Jubbulpore town and is used in the pottery works of Messrs. Burn & Co. and of the Perfect Pottery Co. But a certain amount of clay was won by the Katni Cement and Industrial Co. at Tikuria near Katni. The Madras production is derived chiefly from the districts of Ganjam, South Kanara, Ramnad, Tinnevelly, Trichinopoly. For reasons of drop in Burma and Madras figures for 1913 see foot-note to table 11.

For the Central Provinces the following statistics are available of the production of *fuller's earth* at Katni in the Jubbulpore district, where it is found in the Lower Vindhyan series:—

	Quantity.	*Value.*
	Tons.	£
1909	97	*32*
1910	84	*28*
1911	118	*39*
1912	98	*32*
1913	103	*34*

A form of fuller's earth known as *multani-matti* is also worked in the States of Bikanir and Jaisalmer in Rajputana. A production of 1,000 tons of fuller's earth was returned in 1913 for Marwar in Rajputana, and of 30 and 52 tons in the years 1911 and 1912 respectively for the Anantapur district, Madras.

Pottery clays are worked in various parts of India, amongst which may be mentioned Jubbulpore (from the Jubbulpore division of the Gondwanas).

In addition to the common clays used by the native potter in making common earthenware articles by means of the potter's wheel, there are in India many clays of finer quality used in large pottery works, such as those of Jubbulpore and Raniganj, where, however, the chief productions are drain-pipes, roofing and flooring tiles, fire-bricks, etc. There can be little doubt that India possesses also all the materials necessary for the manufacture of porcelain of the highest quality, such materials being found in the Jubbulpore district and the Rajmahal Hills.

The china-clay and fire-clay deposits of the Rajmahal Hills were investigated by Mr. Murray Stuart,[1] who reports most favourably on their suitability for manufacturing porcelain and fire-bricks of the highest quality.

The Calcutta Pottery Works has been using kaolin from Mangal Hat in the latter area and has succeeded in producing cups, saucers, jugs, and ornaments of common white porcelain.

Testing of Indian clays.

During the period of the previous review, a series of 95 samples of Indian clays was subjected to a critical examination at the Imperial Institute, and a report on them submitted by Professor W. R. Dunstan. The clays were carefully inspected, and a number of samples typical of the various groups were selected and submitted to complete chemical analysis. The remainder were subjected to working and firing trials with a view to the observation of their plasticity, refractoriness, and the nature of the product obtained on firing, which are the properties on which the commercial and manufacturing value of clays depend.

The series of clays was divided into two groups (1) kaolins and (2) terra-cotta clays, the latter group comprising by far the larger number of the samples.

[1] *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 133—148, (1909).

The *kaolins* examined were usually of inferior quality, and not in a sufficiently good mechanical condition to be suitable for the manufacture of thin wares such as those produced by 'slip' casting, though it is probable that by careful levigation some of them could be rendered suitable for working by this process.

The *terra-cotta* clays are suitable for the manufacture of stoneware, ornamental vases and tiles, and bricks of good quality. The following analyses are given:—

TABLE 120.—*Analyses of Indian clays.*

—	1	2	3	4	5	6
Potash	0·61	0·21	*Nil*	0·24	0·24	0·07
Soda	0·41	0·25	*Nil*	0·72	0·51	0·26
Lime	1·85	0·13	0·26	*Nil*	0·46	0·30
Magnesia	1·32	0·54	1·63	0·48	3·09	*Nil*
Manganous oxide	0·12	..	*Nil*	..	..	..
Ferrous oxide	0·67	0·45	0·58	0·51	4·02	2·38
Ferric oxide	0·66	1·61	1·16		3·47	4·81
Alumina	32·75	24·82	21·06	13·04	20·28	21·22
Titanic oxide	0·51	..	0·35	..	0·61	trace.
Silica	46·31	64·06	69·95	80·15	56·21	61·43
Carbon dioxide	2·02	..	0·02	..	2·05	0·72
Water	12·40	7·70	4·69	4·75	8·86	9·42
	99·63	99·77	99·70	99·89	99·80	100·61

NOTES.—No. 1. Prepared white kaolin; from N. Arcot, Madras.

No. 2. Soft pale grey kaolin; from Hoshangabad, Central Provinces.

No. 3. Soft white kaolin with some pinkish material; from Bangalore, Mysore.

No. 4. White impure kaolin, subjected to levigation before analysis; from Shillong, Khasi and Jaintia Hills.

No. 5. Prepared grey clay from Bagirhat, Bengal; a good example of a terra-cotta clay.

No. 6. Dark brown clay with red and yellow ochre in large specks; from Hanthawaddy, Burma.

Of the clays represented by the above analyses, No. 1 was reported to be suitable for the manufacture of good quality earthenware or porcelain; No. 2 for the same purpose after careful preparation; No. 3 is highly refractory and suited for the manufacture of fire-brick or earthenware; No. 4 would be suitable for fire-bricks or to reduce shrinkage when mixed with kaolin; Nos. 5 and 6 are suited for the manufacture of terra-cotta ware.

Imports.

The imports of materials coming under this section,—namely, earthenware and porcelain, earthenware piping, bricks and tiles, and clay,—are shown in table 121, from which it will be seen that there has been an increase, during the six years 1908-09 to 1913-14, from £400,659 in 1908-09 to £611,594 in 1913-14, with an average annual value of £462,677, as compared with an average annual value of £297,606 during the preceding five years. As the average value of the exports and re-exports of clay and clay products during the period has amounted only to £32,264, the total Indian consumption of such products exceeds the internal production by £430,413, indicating considerable scope for the development in the country of industries making use of clay.

TABLE 121.—*Value of Imports into India of Clay and Clay Products during the years 1908-09 to 1913-14.*

YEAR.	Earthenware and porcelain.	Earthenware piping.	Bricks and tiles.	Clay.	**Total annual imports.**
	£	£	£	£	£
1908-09	286,445	3,858	100,688	9,668	**400,659**
1909-10	297,012	4,497	87,493	9,631	**399,133**
1910-11	311,645	14,425	98,423	11,630	**436,123**
1911-12	362,218	8,006	77,235	8,694	**456,153**
1912-13	371,984	3,626	89,630	7,160	**472,400**
1913-14	428,591	2,306	168,437	12,260	**611,594**
Average .	*342,983*	*6,120*	*103,651*	*9,840*	*462,677*

Cobalt.

Cobaltite, a sulph-arsenide of cobalt, and danaite, a cobaltiferous arsenopyrite, have been found as minute crystals in the slates of the Aravalli series at Khetri [1] and other places in Rajputana. These ores have been used for the manufacture of various sulphates. The minerals were formerly separated for the production of *sehta*, which is used by the Indian jewellers for producing a cobalt-blue enamel. The sulphide of cobalt, linnæite (Co_3S_4), has been recently identified in the Geological Survey Laboratory amongst some ores of copper sent from Sikkim by Colonel Newcomen. Some years ago specimens of a matte containing 11 per cent. to 14 per cent. of cobalt, the rest being iron and sulphur, were received in the Geological Survey Office, but no details as to the mode of occurrence have ever been received.[2] Small quantities of cobalt and nickel are frequently detected in the Indian manganese-ores. The best sample is the cobaltiferous wad of Olatura in the Kalahandi State, a specimen of which yielded 0·82 per cent. of cobalt oxide (CoO).

Copper.

Copper was formerly smelted in considerable quantities in Southern India, in Rajputana, and at various places along the outer Himalayas in which a persistent belt of killas-like rock is known to be copper-bearing in numerous places, as in Kulu, Garhwal, Nepal, Sikkim, and Bhutan. In Chota Nagpur several attempts have been made to work lodes reputed to be rich in the metal, but in all such attempts the ore has been smelted for the metal alone and no effort has been made hitherto to utilise the accompanying sulphur as a bye-product. At Baraganda in the Giridih sub-division of Hazaribagh, a low-grade ore-body of about 14 feet in thickness has been prospected by shafts to a depth of 330 feet, and an unsuccessful attempt was made some years ago to work the ore.

Singhbhum.

In the Singhbhum district (Bihar and Orissa) a copper-bearing belt marked out by old copper workings persists for a distance of some 80 miles, stretching from Duarparam on the Bamini River in the Kera Estate, in an easterly direction through the Kharsawan and Saraikala States, into Dhalbhum, where the strike of the belt curves

[1] *Rec. Geol. Surv. Ind.*, XIV, pp. 190—196, (1887); see also A. M. Heron, *Rec. Geol. Surv. Ind.*, XLIV, p. 19, (1914).

[2] E. J. Jones, *Rec. Geol. Surv. Ind.*, XXII, p. 172, (1889).

round to south-east, running through the Rajdoha and Matigara properties of the Cape Copper Company, Ltd., to Bhairagora at the extreme south-east end.

The copper-ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists; sometimes the ore is collected into fairly well defined bands, but very frequently it occurs in the form of grains so sparsely disseminated through a considerable thickness of schists as to be unworkable; whereas, if the same amount of copper minerals had been concentrated into smaller thickness of schists, workable deposits of ore would have been formed. When concentrated into definite lodes, as at Matigara, the ore may be of fairly high grade, and well worth working, if it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore.

These copper-ores have been the subject of exploitation on European lines by various companies during the past fifty years, always until lately with disastrous results, in some cases due to the poor character of the deposit attacked, and in others to the unwise expenditure of a limited capital on expensive plant before the deposit had been proved. Such results caused business and mining men to avoid the Singhbhum copper and consequently, in the absence of private enterprise, the Geological Survey of India, during the years 1906 to 1908, carried out a series of diamond-drilling operations on the belt. This directed attention to the problem, and the Cape Copper Company, having secured an option from the Rajdoha Mining Company, has for some years been carrying on development work in the Gladstone Shaft at Matigara, supplemented by diamond-drill bore-holes along the strike of the lode, with the result that the option was exercised in 1913 By the end of 1914 the Gladstone Shaft (No. 1) had been deepened to over 1,000 feet on the dip, whilst vigorous development work had been carried out in a series of levels along the strike Another shaft, No. 4, has been sunk to over 300 feet at a point 3,500 feet south-east of No 1, and at the end of August 1914 the ore reserves calculated on a width of 3 feet amounted to 307,747 short tons containing over 12,000 short tons of copper, or an average copper contents of 3·9 per cent. A concentration plant, with electric power house, is now being erected for treating the ores on the spot. Whilst waiting for this a certain amount of hand-picked ore was exported to Swansea during the period under review. In the course of development

work at Matigara there has been a small annual production of copper-ore, details of which are shown in table 122. The average daily number of coolies employed during the quinquennium was 1,385.

TABLE 122.—*Production of Copper-ore during 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa .	7	(a) *11*	864	*2,304*	2,079	*2,911*	8,984	*13,476*	3,639	*6,085*	3,115	*4,957*
Burma . .	..	..	290	*579*	159	*493*	624	*209*	150	*2,530*	244	*762*
United Provinces	..	..	2	*4*	..	..	11	*24*	16	*35*	6	*13*
Mysore . .	..	..	..	..	..	..	..	..	5	Not given.	1	..
Total .	7	*11*	1,156	*2,887*	2,238	*3,404*	9,619	*13,709*	3,810	*8,650*	3,366	*5,732*

(*a*) Estimated @ £1 12*s*. per ton on the average basis of 1910-13 figures from Singhbhum.

As seen at the outcrops the Singhbhum lodes seem to be very poor indeed where they have not been removed by the ancients. Typically they consist of a small thickness of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small quantity of copper, possibly as red oxide, with sometimes small encrustations of liebethenite. In depth, as seen in the diamond drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite. The other minerals noticed above are evidently the outcrop alteration products of the yellow sulphide. Judging from small specimens found on the dump-heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably been deposited in their position as rather indefinite lodes following the bedding of the schists, subsequent to the arrival of the schists in their present position. The schists with which the copper lodes are associated are chiefly varieties of muscovite- and chlorite-quartz-schists, with quartzite layers. Apatite and tourmaline are also common minerals in these schists.

The information obtained in the borings put down by the Geological Survey is shown in table 123.[1] These results show that, generally speaking, the ores of Singhbhum are of low grade, and on the whole just below what is likely to be payable, except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. copper found at Laukisra, should, however, lead to the further testing of this occurrence by private enterprise.

The characteristic and persistent band of chalcopyrite with quartz blebs intersected by the Matigara bore-hole at 736 feet, where it yielded 12·81 per cent. of copper, but was only 3 inches thick, and which was seen in the Matigara mine in the 228-foot level with a thickness ranging from 6 inches to 2 feet, has now been followed on the dip in the Gladstone Shaft and proved to extend below the depth proved by boring.

TABLE 123.—*Results of Diamond-drill Boring on the Singhbhum Copper Lodes.*

No. of bore-hole.	Locality.	Total depth of hole.	Depth of lode or cupriferous zone.	Actual thickness of lode assayed.	% of copper.
1	Kodomdiha . .	..	392′—404′	8 feet . .	5·10
2	Do. . .	1,093′	1,069′	1 foot . .	1·82
3	Galudih (Regadih) .	430′	131′—294′ 293′	.. 13 inches . .	.. 0·61
4	Landup (Nadup) .	465′	197′—198′	14 inches . .	3·33
5	Matigara . .	837′	693′—697′ 697′—701′ 8″ 733′ 5″—736′ 1″ 736′ 1″—736′ 5″ 736′ 5″—739′	3 feet 2 inches . 3 feet 8 inches . 2 feet 1 inch . 3 inches . . 2 feet . .	2·00 1·29 1·01 12·81 0·42
6	Laukisra . .	392′	150′—168′ 169′—171′ 179′—184′	16 feet 10 inches . 1 foot 10 inches . 4 feet 8 inches .	2·65 2·13 1·37

Himalayas.

With reference to copper in the Himalaya, attention may be drawn to a note on a copper deposit near Komai, Darjeeling district,[1] and to one on the copper of Garhwal and Kumaon.[2]

Sikkim.

Recent work has also proved the existence of valuable lodes in Sikkim, where the copper is associated with bismuth, antimony, and tellurium, one of the minerals discovered being the rare mineral tetradymite, Bi_2Te_3. Another mineral identified by Mr. Blyth in the Geological Survey Laboratory is linnæite, a sulphide of cobalt, Co_3S_4.

Prospecting licenses and mining leases have been secured by Messrs. Burn & Co. in the copper-bearing areas in Sikkim, where prospecting operations were conducted during 1907 and 1908 by Messrs. C. Wilkinson and C. E. Simmonds.

The following notes are obtained from a report made in October 1908 by Mr. C. Wilkinson, showing the principal results obtained up to that date[3] :—

At Bhotang, 44 miles from Siliguri on the road to Gangtok, some old workings were examined and two parallel lodes of pyrrhotite were opened up and found to contain varying quantities of zinc blende, galena, and chalcopyrite. The lodes are considerably disturbed, but considerable development work carried out during the last three years has yielded results that are considered to be satisfactory.

At Dikchu, about 7 miles to the north of Gangtok and within a mile of the Gangtok-Lachen road, a distance of 75 miles from Siliguri, a better defined copper-lode was found. It was found, by opening up the outcrops for a length of 200 feet along the bed of the Sehchu, that the lode had an average width of 3 feet, bearing 6·14 per cent. of copper. By cutting the vein at a greater depth with an adit it was found that for 80 feet on an average width of 40 inches the lode contained an average content of 6·8 per cent. of copper.

In the Rhotak Colah, a tributary of the Great Ranjit river, 13 miles by pack road from Darjeeling, there are extensive old workings which have been almost obliterated by landslips. Five samples

[1] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXI, p. 1, (1904).
[2] J. Coggin Brown, *Rec. Geol. Surv. Ind.*, XXXV, p. 35, (1907).
[3] Published with the kind consent, through the late Mr. A. Whyte, of Messrs. Burn & Co.

of the lode, taken at irregular intervals along a length of 500 feet, give an average of 5·6 per cent. of copper.

At Sirbong, about 1 mile north-east of the junction of the Rhotak and Khani Colahs, a lode of pyrrhotite containing chalcopyrite was exposed, yielding, for an average thickness of 2 feet 6 inches, 6·45 per cent. of copper, the sampling being continued for about 100 feet along the outcrop.

The Pachikhani mine, which is reputed among the natives to be one of the richest of the mines in Sikkim, has been overwhelmed by a landslip, and has not yet been sufficiently opened for further examination (see Mr. Bose's remarks on this mine).

Another deposit was found near Pachikhani on the road from Rungpo to Pakyong, about 7 miles from the former locality. It was found that the chalcopyrite, concentrated within a zone of mica-schist about 4 feet wide, yielded on an average 4 per cent. of copper, and it is proposed to test the occurrence more fully by diamond drilling.

Within 200 yards of the bridge crossing the Rungpo on the road from Rungpo to Rhenock, and about a mile to the north-east of the second of the two Pachikhani mines, there was found a quartzose vein following the schist-planes of the Daling series and containing 3·97 per cent. of copper for an average thickness of 1 foot; it is considered that this ore can be readily concentrated by hand picking.

In the neighbourhood of Pakyong in the Pachi Colah valley, two veins were found outcropping at right angles to the stream and at a distance of 200 yards from each other. The average analysis of the samples collected from one of these lodes gave the following results:—

Copper	3 30
Iron	11·23
Lead	10·10
Zinc	2·50
Sulphur	11·68
Silica	40·10

The other lode, consisting mainly of galena, varied in thickness from 6 inches to 2 feet, and contained an average of 21·12 per cent. of lead with 5·9 per cent. of zinc.

In 1911 the two most important of these deposits, namely, Bhotang and Dikchu, were examined by the Geological Survey of India.[1] As the result of this examination, development work was resumed at Bhotang with favourable results. Both deposits occur interbedded with the associated rocks, being of the nature of interbedded replacement deposits; but whereas the Bhotang deposit is in a comparatively unmetamorphosed form of the Daling series, the Dikchu deposit occurs in the belt of highly crystalline mica-schists with associated gneisses, forming a boundary zone between the Daling series and the Sikkim gneiss. In both cases, the copper-ore is chalcopyrite, the chief associated sulphide being pyrrhotite. But, especially at Bhotang, galena and blende are also of somewhat common occurrence. The origin and mode of occurrence of these ores appear to be similar to those of the Singhbhum copper-lodes. In each area the lodes are interbedded in the Archæan rocks (Dharwars in Singhbhum and Dalings in Sikkim, the garnetiferous rock of Dikchu being probably a highly metamorphosed form of the Dalings); in each area the bodies of copper-ore have been formed by the metasomatic replacement of the associated rocks; and in each area the copper-bearing formations are close to large masses of granitic rocks, from which, one may conjecture, the copper-bearing solutions were derived. In Singhbhum there are numerous basic (epidioritic) dykes associated with both the granites and the Dharwar rocks (schists, quartzites, etc.), and, as an alternative to the derivation of the copper-bearing solutions from the granites, it is possible to suppose them to be closely connected with the basic dykes. The disposition of the Singhbhum copper deposits as an aureole in the Dharwars following the curvature of the Dharwar-granite boundary is, however, in favour of the former suggestion, which, as it happens, is also more suitable for explaining the derivation of the ores of Sikkim, where basic igneous intrusions are scarce.

Although the deposits of Sikkim are similar in mode of origin to those of Singhbhum, they differ from them remarkably in the diversity of their mineral contents, which frequently include chalcopyrite, pyrite, pyrrhotite, blende, and galena; in Singhbhum, on the other hand, the copper-lodes show, as a rule, only two sulphide minerals, chalcopyrite and pyrite—with traces of chalcocite at higher levels, probably representing a zone of secondary enrichment.

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLII, p. 75, (1912).

In both Sikkim and Singhbhum, azurite, malachite, chrysocolla, and chalcanthite are found in the oxidised zones of the lodes, but in Sikkim, where the slopes are very steep and denudation under the influence of a moist climate and heavy rainfall is very rapid, the oxidised zones are much less prominent than in Singhbhum. In Sikkim the sulphide minerals may crop out at the surface in the fresh condition, but this practically never happens in Singhbhum, where one might doubt the existence of copper deposits, were it not for the presence of numerous ancient outcrop workings stained with green and blue oxidised copper minerals.

Conditions bearing on mineral exploitation of Sikkim.

The principal rivers of Sikkim, the Tista and the Great Ranjit, while carrying large volumes of water, are useless as means of transport, having many rapids in their courses and being subject to sudden, violent floods. Roads for the most part are few and far between, so that communication between the opposite points of their banks is often a question of making a detour of 10 or 12 miles. To work mineral deposits in this area requires transport by coolies, mules, or bullock carts, where the hill roads are kept in a fair state of efficiency, as they generally are throughout the State. The roads are liable to damage during the monsoon by landslips, and consequently the suggestion to build a railway from Siliguri to Rungpo is looked upon as a costly undertaking.

Aerial cable-ways can be utilised from mine to mine, or from mine to main roads, for the purposes of exploitation. Coolie labour for transport and surface work is fairly abundant. The local people are not accustomed to underground work, but there are colonists from Nepal, who have been by caste hereditary miners for many generations.

There is at present an abundance of timber in Sikkim: in the higher regions there occur oak, beech, walnut, pine, yew and chestnut; in the lower regions sal and simul. All of these are suitable for mining timber.

Running water is abundant, and, in places, might be utilised, without much expense, for generating electric power, as, for instance, in the rapids of the Tista near Rungpo, in the Dikchu, and near the junction of the Lachen and Lachung rivers. Arrangements have indeed been made to test in France the practicability of smelting hydro-electrically samples of ore from the Bhotang mine where development work has meanwhile been closed down, and on the success of these experiments much probably depends.

Burma : Northern Shan States.

Copper-ore is also found in association with the lead-zinc ores of Bawdwin, in the Northern Shan States, but not, it seems, in quantity, and the Chinese do not appear to have made any use of it. They smelted, however, a small amount of copper-ore in the vicinity of Bawdwin. The copper minerals found at Bawdwin are chalcopyrite, azurite and malachite.[1] Copper-ore also occurs at Taungbalaung in the Myitkyina district. The production for 1910 and 1911 recorded in table 122 refers to this locality and that for 1912 and 1913 to the Northern Shan States (Bawdwin).

Indian consumption of copper and brass.

That there is plenty of scope for the development of copper deposits in India to satisfy the Indian demand is seen by the magnitude of the imports of copper and brass. The average annual values of these for the period under review are shown in table 124, together with the exports of Indian copper and brass wares (manufactured from imported metal, of course), and the re-exports of foreign copper and brass. From these it is seen that the average annual consumption has been £2,066,395 of copper and £70,008 of brass, which represent increases of 58 per cent. and 46 per cent. respectively over the previous quinquennial period.

TABLE 124.—*Average Annual Exports and Imports of Copper and Brass for the six years 1908-09 to 1913-14.*

——	Copper.		Brass.	
	£	£	£	£
IMPORTS	..	2,115,135	..	88,429
EXPORTS—				
Of Indian merchandise	18,823		16,361	
Of foreign merchandise	25,892		1,837	
Of Government stores	4,025		223	
TOTAL EXPORTS	48,740	48,740	18,421	18,421
Indian consumption	..	**2,066,395**	..	**70,008**

[1] T. D. LaTouche and J. Coggin Brown, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 241, 247, 249, 256, (1909). See also *Rec. Geol. Surv. Ind.*, XXXIII, p. 342, (1906).

Corundum.

The use of abrasives in manufacturing communities seems to be on the increase, and new forms are being put on the market yearly. Emery formerly served most requirements, until purer forms of corundum were discovered in quantity. The cheaper forms of garnet have long been used to adulterate emery, and members of the spinel family, such as hercynite, have been used inadvertently as such. During the last twenty years carborundum, manufactured by the cheap electrical power developed in America, has come into use, the production of the United States having now reached nearly 6,000 tons a year. Two artificial forms of corundum (alundum and aloxite) are being manufactured from bauxite and emery, respectively, at Niagara, and crushed steel is being used to an increasing extent.

Natural corundum has thus many competitors in the market of abrasive materials, and as a large portion of the alumina in igneous magmas is necessarily used up during the processes of consolidation by the silica and bases present, it is theoretically unlikely that the free oxide can exist anywhere in an abundance comparable to the vast quantities of combined alumina in the earth's crust. In most cases the corundum is scattered as isolated crystals through the rock, and only the most economical devices for its separation can make mining remunerative.

In India, where the use of corundum by the old *saikalgar* (armourer) and lapidary has been known for many generations the requirements of the country have been met by a few comparatively rich deposits, but it is doubtful if these are worth working for export in the face of the competition referred to above in Europe and America, or will even stand against the importation of cheap abrasives.

There is still, and for many generations has been, a certain trade in Indian corundum, but the returns for production are manifestly incomplete. No workings exist of the kind that could be ordinarily described as mining, but attempts have been made at times to increase the scale of operations at Palakod and Paparapatti in the Salem district, near Hunsur in Mysore, and in South Rewah. Such production figures as are available are summarised in table 125.

TABLE 125.—*Production of Corundum in India for the five years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£
Assam (Khasia and Jaintia Hills).	..	..	..	..	..	..	1,400	*140*	..	..	280	*28*
Central India (Rewah) (*a*).	378	*103*	1,055	*311*	180	*62*	460	*156*	1,860	*868*	787	*300*
Hyderabad . .	Not reported.	*6*	..	..	Not reported.	*3*	..	..	..	..	..	*2*
Kashmir (*b*) . .	..	..	..	..	5	Not reported.	..	..	..	..	1	..
Madras . . .	..	..	1,686	*323*	3,491	*1,660*	2,931	*532*	1,951	*324*	2,012	*568*
Mysore . . .	436	*87*	2,152	*430*	2,505	*501*	2,926	*585*	4,149	*830*	2,434	*487*
TOTAL .	814	*196*	4,893	*1,064*	6,181	*2,226*	7,717	*1,413*	7,960	*2,022*	5,514	*1,385*

(*a*) The value figures are merely royalties obtained by the State.
(*b*) Blue corundum.

Production.

The occurrence near Pipra in Rewah State has been worked during the period by Indian traders of Mirzapur. The production during the five years 1909-13 is shown in table 125.

Corundum is very widely distributed throughout the Mysore State and is said to occur in every district except Shimoga. During the years 1912 and 1913 it was obtained in the following districts, by far the larger proportion coming from the first named:—Tumkur, Mysore, Kolar, Hassan, Bangalore. The average annual production during the quinquennium was 2,282 cwts. valued at £456.

Of the production of corundum recorded from the Madras Presidency the bulk was derived from the Trichinopoly district, with smaller amounts from Nellore and Coimbatore.

Much of the corundum, which is a regular item of trade in the bazaars of cities like Delhi, Agra, and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cowherds, who dispose of it through the village *bania* to the larger dealers of the great cities. Our information as to the mode of occurrence and distribution of the mineral was summarised in a special memoir published by the Geological Survey in 1898.

Khasi Hills.

Corundum (*mawshinrut*) is known to occur at three localities in the Nongstoin State in the North-West Khasi Hills. The localities are too difficult of access for the exploitation of the mineral on a large scale, but it is worked in small quantities and used all over the Khasi Hills for hones.[1]

Gem varieties of corundum are treated, of course, under 'Gem-stones.'

Canadian corundum.

The chief producers of corundum and emery are Canada, Turkey, and Greece, Canada supplying corundum, and Turkey and Greece emery. The Canadian corundum is found in Ontario in association with nepheline-syenite like that near Kangayam in the Coimbatore district.[2] By the adoption of mechanical means for concentration it has become possible to separate corundum from the felspar-rock in which it is embedded, and to put a product on the market, not only for local use, but for export to the United States and Europe.

The Canadian industry commenced in 1900, and the annual production for the last five years has averaged 1,594 tons valued at £36,953.

Fluor-spar.

Fluor-spar has been obtained at Barla in the Kishengarh State, Rajputana, but the work of excavation was abandoned under a mistaken impression that the mineral was an inferior form of amethyst. Apparently the mineral forms with calcite and quartz a vein about a foot in thickness traversing gneiss. This occurrence is again being investigated, this time by the Tata Iron and Steel Co., who import from 300 to 400 tons of fluor-spar annually for use as a flux in the manufacture of steel. Fluor-spar has also been found as small crystals in a dyke of quartz-porphyry near the copper-ore lodes of Sleemanabad, Jubbulpore district.[3] Other localities recorded for the mineral are Ranitalao, Raipur district,[4] where it is associated with galena; near Rewah[5] in one of the Vindhyan limestones; in the granitic veins of the Sutlej valley, North-West

[1] F. E. Jackson, *Rec. Geol. Surv. Ind.*, XXXVI, p. 323, (1908).

[2] T. H. Holland, 'The Sivamalai series of Elæolite and Corundum-Syenites,' *Mem. Geol. Surv. Ind.*, XXX, pt. 3, 1901.

[3] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 63, (1906).

[4] W. T. Blanford, *Rec. Geol. Surv. Ind.*, III, p. 44, (1870).

[5] F. R. Mallet, *Mem. Geol. Surv. Ind.*, VII, p. 122, (1871).

Himalayas,[1] and in limestone in the Amherst district, Burma. No indication of large deposits has been noticed at any of the localities.

Gem-stones.

The most valuable of the precious stones raised in India is undoubtedly the ruby, but this and the other stones obtained in the country do not approach in value the unset stones and pearls imported, which, during the period under review, had an average annual value of £623,130 (compared with £595,078 during the previous quinquennium).

Of the precious and semi-precious stones in India, the most important, amber, diamond, jadeite, ruby, sapphire, and spinel, have been already referred to. Of the others, the only ones that are of immediate concern are agate, rock crystal, beryl, garnet, tourmaline, and turquoise. All of these except the last have been or are still being worked to some extent in India, and the turquoise may be dismissed with the mere mention of the fact that India, besides being a large importer for local use, is one of the channels by which the material raised in Persia and adjoining areas reaches the European and Eastern market. The other minerals—with some other Indian stones at present used very little or not at all—deserve more particular mention.

Agate.

There is still a considerable trade in agate and the related forms of silica, known under the general name of *hakik*, and obtained from the amygdaloidal flows of the Deccan Trap. The best known and perhaps still the most important of the places at which agate and carnelians are cut and prepared for the market is Cambay, the chief city of the State of that name under the Kaira Political Agency, Bombay Presidency. The agates come from various states and districts on or near the edge of the trap, but mostly from the State of Rajpipla. An account of the Rajpipla agate industry has been given recently by Mr. P. N. Bose.[2] The agates occur in a conglomerate of probable Pliocene age, and have been worked chiefly at Ratanpur and Damlai. The stones are chipped at the mines, and those approved of taken to Limodra, where they are baked. The baked stones are sent to Cambay for cutting and polishing. The

[1] F. R. Mallet, *Mem. Geol. Surv. Ind.*, V, p. 166, (1866).
[2] *Rec. Geol. Surv. Ind.*, XXXVII, pp. 176—182, (1908).

Rajpipla *hakik* mines are leased for periods of five years at a fixed annual rental or royalty. This was Rs. 3,000 a year for the period 1902-06. No precise data as to the value of the stones sent to Cambay are available. The production from the Rajpipla mines in 1913 is returned as 103 tons of 'carnelian stones' valued at £250. A certain amount of agate-cutting is also carried on at Jubbulpore in the Central Provinces, at Banda in the United Provinces, and at a few other places within range of the Deccan Trap.

Much of the agate retailed in Europe is sent from Cambay, and large quantities are also exported to China.

Various forms of quartz—rock-crystal, amethyst, etc.—are used by jewellers in various parts of India.

Rock-crystal.

In the Tanjore district, Madras Presidency, fragments of rock-crystal are collected and cut for cheap jewellery, being known as 'Vallum diamonds,' whilst the bipyramidal quartz-crystals, found in the gypsum of the salt-marl near Kalabagh, on the Indus, are to a certain extent used for making necklaces; rock-crystal is similarly used for cheap jewellery in Kashmir. Fine pieces of rock-crystal are sometimes cut into cups, sword handles, and sacred objects, such as lingams, in Northern India.

Amethyst and rose-quartz.

Small amethysts, usually of uneven colour, are obtained at many places from Deccan Trap geodes, *e.g.*, in the bed of the Narbada near Jubbulpore, and used for jewellery and beads. Amethyst is common in the Sutlej valley in Bashahr, Punjab.[1] Rose-quartz is found at several places [2] and could also be used in cheap jewellery.

Apatite.

Green apatite derived from pegmatites in Ajmer in Rajputana is sometimes cut into gem-stones, and a considerable quantity of apatite of a rich sea-green has been found at Devada, Vizagapatam district, Madras, probably from a pegmatitic variety of kodurite.[3]

Beryl.

Beryl in its pale-coloured varieties is of common occurrence in the granite-pegmatites of India, but the crystals are generally too much fissured for use as gem-stones. Occasionally in the pegmatite veins which are worked for mica in Behar and in Nellore, large crystals

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 212, (1909).
[3] *Op. cit.*, p. 206.

of beryl, many inches across, are found to include clear fragments which might be cut as aquamarines; but the only places in India where attempts have been made to excavate pegmatite solely for its aquamarines are at Padyur (Pattalai) near Kangayam, Coimbatore district, and at different places in the Toda hills in Rajputana. Stones of considerable value were obtained from the mine which was worked at Padyur in the early part of the nineteenth century: a pit some 30—40 feet in depth is still in existence, but no one seems to have taken an interest in the place since J. M. Heath held a lease in 1818. The whole area is impregnated with igneous intrusions, and deserves more attention than it has so far received.

At Sagar near Sarwar in the Kishangarh State, Rajputana, aquamarines occur in mica-bearing pegmatites.

Chrysoberyl.

Platy crystals of this mineral have been found in the corundum-bearing felspar-veins near Kangayam in the Coimbatore district, associated with nepheline-syenites; but the crystals are too highly flawed to be suitable for gems. Yellow crystals, transparent and of good quality, are said to occur with mica and aquamarine in pegmatite veins at Govindsagar, Kishangarh State, Rajputana.

Garnet.

The only garnets worked to any considerable extent in India occur in the mica-schists of Rajmahal in Jaipur State, at Shahpura in Udaipur State, in the Sarwar district of Kishangarh State, and in the district of Ajmer-Merwara, all these localities being within a relatively small distance of each other. Returns are not available to show the condition of the industry in the Jaipur State, but the statistics obtained indicate the existence of a considerable industry in the other areas. See table 126.

These returns indicate a considerable decrease in the output of Ajmer-Merwara and of Shahpura, and an increase in the output of the Kishangarh State. The Kishangarh garnets are stated to be the finest in India.

The garnets being worked in India belong to the almandite variety, and have a purple colour. Stones of large size are obtained and their cutting for the market forms an important industry in Jaipur and Delhi.

Gem garnets are also found in other parts of India, as in the Tinnevelli district, Madras,[1] and used locally. Attention may also

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234, (1906).

be drawn to the fact that the manganese garnet, spessartite, so characteristic of the gonditic rocks of the Central Provinces, is in America sometimes used as a gem. The Indian variety varies from a beautiful bright orange to red-brown, but has not yet been found sufficiently free from flaws to be of use as a gem.[1]

TABLE 126.—*Production of Garnet in India during the years 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£
Ajmer-Merwara .	9	*97*	1½	*43*	21	*281*	11½	*77*	16	*70*	12	*114*
Kishangarh (Sarwar)	384	*2,884*	318	*1,842*	233½	*1,845*	178½	*600*	50	*1,134*	253	*1,661*
Udaipur (Shahpura) .	..	..	..	..	..	..	1	*3* (b)	46	*84*	9	*17*
Hyderabad . .	..	..	..	..	..	..	..	..	122	Not reported.	24	..
Madras (Nellore) .	..	..	..	..	..	..	1	(a)	..	..	..	..
TOTAL .	393	*2,981*	319½	*1,885*	254½	*2,126*	192	*680*	234	*1,288*	298	*1,792*

(a) Value returned at Rs. 4.
(b) The garnet production of some years was sold in 1912 for Rs. 7,487-8-10 or £499.

Iolite.

Cordierite or iolite, a mineral exhibiting striking pleochroism, is found in the gem gravels of Ceylon, and cut as a gem under the name of lynx-sapphire and water-sapphire. A polished and roughly engraved piece of iolite found in some excavations at Budh Gaya, and showing strong pleochroism, deep violet to nearly colourless, has long been in the Indian Museum, but no locality for the mineral was known.[2] It has now been found at two localities, namely, in complex rocks composed of sillimanite, hypersthene and biotite, in the Vizagapatam Hill-tracts,[3] and in the Kadavur Zemindari, Trichinopoly district, Madras, where Mr. P. N. Bose reports its occurrence in abundance near Udaiyapatti and Kiranur, associated with labradorite and mica-schist. There are ancient pits, dug apparently for this mineral.

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 604, (1909).
[2] V. Ball, *Proc. As. Soc. Beng.*, 1881, p. 89.
[3] T. L. Walker, *Rec. Geol. Surv. Ind.*, XXXVI, p. 13, (1908).

Kyanite.

Kyanite is found at many localities in the Archæan formations of India and is occasionally used as a gem-stone on account of the fine blue colour it sometimes displays.[1] An authenticated locality for gem kyanite is Narnaul, Patiala State. The jewellers at Patiala call it *bruj*, and say that it sells at Rs. 3 to Rs. 5 per tola, equivalent to 10*s*. to 16*s*. 8*d*. per ounce.[2] Kyanite is also plentiful in Kanaur and Bashahr in the Punjab Himalayas,[3] where it has often been mistaken for sapphire.

Rhodonite.

Rhodonite, a manganese-pyroxene, is used abroad (*e.g.*, in the Urals) as a gem and cut into all kinds of ornamental objects. It is found at many localities in India associated with manganese-ore deposits; and although none of it has yet been used for ornamental purposes, suitable material for the manufacture of small objects could be obtained at several of the mines.[4]

Tourmaline.

The beautiful red tourmaline, known as rubellite, is worked on a small scale in the Ruby Mines District of Upper Burma. The production during the four years 1904 to 1907 averaged 101 lbs. valued at £750. Since then no figures have been received.

An interesting report was published in 1908 by Mr. E. C. S. George, Deputy Commissioner of the district,[5] on the workings for tourmaline round the small Palaung hamlet of Sanka about a mile east of Maingnin, where operations were carried on by the Chinese, according to local tradition, some 150 or 200 years ago. Mr. George states that after the Chinese deserted the area, the Kachins reopened the mines about forty years ago, but the industry was again interrupted until about 1885, when more systematic operations were commenced under Pu Seinda, who contracted to conduct all mining operations until 1895. The Möng-mit (Momeit) stone-tract was afterwards notified by Government and regular licenses were taken up in 1899. During the years 1903 to 1905 the amounts recovered from 'tourmaline licenses,' the rate being Rs. 2 per worker per month, have been Rs. 2,000 (£133) to Rs. 3,000 (£200) each year; since then they must have fallen off.

[1] M. Bauer and L. J. Spencer, 'Precious Stones,' p. 415, (1904).
[2] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59, (1906).
[3] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102, (1904).
[4] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 144, 604, (1909).
[5] *Rec. Geol. Surv. Ind.*, XXXVI, pp. 233—238.

The tourmaline is found in soft, decomposed granite-veins, which, being generally covered by a thick deposit of jungle-clad soil, are found rather by accident than through the guidance of any superficial indications. Isolated crystals are found occasionally lying in the red soil, and men with small means sometimes find it profitable, when they have leisure, to search through the soil-cap by digging shallow pits. *Twinlons* or vertical shafts, about 4 or 5 feet square, are also put down on the chance of striking a tourmaline-bearing vein, or *kyaw*, and the owners of these *twinlons* are permitted to extend their workings underground to a radius of five fathoms from the centre of each shaft. Some of the workings extend to depths of about 100 feet, which appears to be about the limit of the miners' engineering skill. The tourmaline found is sorted into three classes: (1) *ahtet yay*, the best light-pink rubellite, of which there are two kinds, *hteik ti*, showing well-developed basal planes, and *be yan*, crystals terminated by rhombohedral faces, or with only a small development of the basal plane; (2) *akka*, of a darker colour with the lower part of the crystals brown or black in colour; (3) *sinzi* or *arnyi*, all fragmentary crystals of any colour which are imperfect, or of a small size, less than about an inch. The *sinzi* is given without charge to the buyer of the lots of the two better kinds. The best kind, *ahtet yay*, may bring as much as Rs. 1,200 to Rs. 1,500 a viss (3·65 lbs.). The *myaw* system or exposure of the veins on the hill-side by hydraulic action, has also been attempted at two localities with uncertain results: this work is limited to the rains and is handicapped by the cost of leading the water-channels for long distances. All locally made purchases are effected by brokers, usually Shans or Shan Burmans. They in turn sell at Mandalay to purchasers for the Chinese market.

In 1909, 7 stones weighing 63·8 ratis or 37·5 carat,[1] valued at £26, were found in the Northern Shan States.

A beautiful green tourmaline with a crystalline limestone matrix is worked in a small way at Namon near the Salween river in the Southern Shan States. Green and blue varieties occur in the pegmatites of some parts of the mica-mining area of Hazaribagh district, but the stones are not worth the cost of extraction.

Green tourmalines are also found at the Sapphire Mines area of Zanskar in Kashmir.

[1] At 1 rati = 1⅞ grains troy = ·592 carat.

Zircon. The mineral zircon is known in various parts of India, and where it occurs in the nepheline-syenite series near Kangayam in the Coimbatore district it is picked up in small quantities and passed into the market as corundum; but it is nowhere found sufficiently transparent and flawless to be used as a gem.

Glass-making Materials.

The common, impure sands of the rivers and the efflorescent alkali salts, so common in many parts of India, are used in various places for the manufacture of the inferior varieties of glass used for bangles.

The chief difficulty in the way of manufacturing the better grades of glass in India is the absence of known deposits of quartz-sand of the requisite purity and of suitable texture. In a few places, however, attempts are being made to introduce European methods and to make a better class of article. The factory at Rajpur near Dehra Dun, known as the Himalaya Glass Works, which started work in 1903, and seemed at one time to be on the road to success, has been closed down. In an interesting blue-book Mr. F. O. Oertel describes a visit to glass-works in England, Austria, and Germany, analyses the causes of failure at Rajpur, and advances suggestions for the guidance of future enterprises of a similar nature. He especially advocates the manufacture of *churi* or bangle glass.[1]

No less than three other glass works have been started under Indian management, namely, the Paisa Fund Glass Works at Talegaon, Poona district, Bombay, in 1908, the Upper India Glass Works at Ambala in 1914, and the Jubbulpore Glass Factory at Jubbulpore. The sand for the Talegaon works is obtained by crushing quartz found locally, and the lime is obtained from Bombay. The sand and lime for the Ambala works are obtained from Dehra Dun; for the Jubbulpore works the sand is local and the lime obtained from Katni. The soda is imported in each case. These factories devote themselves principally to the manufacture of lamp globes and chimneys, bottles and tumblers, but other articles are also produced, especially at Talegaon.

The sands found at various localities in the Rajmahal Hills, and reported to be suitable for glass-making, have been investi-

[1] 'Notes on the Glass Industry in Europe,' Allahabad, (1915).

gated by Mr. Murray Stuart.[1] He concludes that the sand met with in this area is generally unsuitable for the manufacture of any but the commonest kinds of bottles. The sands considered occur as (1) recent river-sands, and (2) Damuda (Gondwana) sandstone.

To what extent a glass-making industry would find a market in India may be judged by the fact that during the past fifteen years the annual imports of glass and glassware have gradually risen in value from £440,000 to over £1,300,000 in 1913, the average value for the period 1909-13 being £1,057,788. The chief items in this total are bangles, beads and false pearls, common bottles, lampware, sheet and plate glass.

Gypsum.

Gypsum occurs in considerable abundance in various parts of India, occurring both in the fibrous form and as clear selenite crystals. In Baluchistan, the Tertiary clays and shales of all ages, whenever they are but slightly disturbed, contain numerous crystals of gypsum scattered throughout their mass[2]; in Sind it occurs in beds sometimes 3 to 4 feet thick near the top of the Gaj beds of the Khirthar range; in Cutch it occurs in abundance in the rocks below the Nummulitic limestones; in the Salt Range it occurs in large masses with the salt marl, lying below Cambrian beds.

A very interesting and, judging by the returns, important occurrence is N.-N.-W. of Nagaur in Jodhpur, Rajputana, where a bed, 5 feet thick or more, occurs in silt probably formed in an old salt-lake. The output from the Nagaur district during the five years 1909 to 1913 is shown in table 127.

Selenite crystals of similar origin to that of Nagaur have been recently found in the kankar near the base of the silt in the Sambhar lake, and are also obtained at Pachbadra during the manufacture of salt from brine.[3] A small gypsum deposit of no economic value also occurs in the Chamba Valley, Dholpur State.[4] There is also a considerable production of gypsum at Jaunsar in Bikanir, Rajputana (see table 127).

New occurrences of gypsum have been discovered in the Vindhyan series at Satna in Rewah State[5] (probably of no economic value);

[1] *Rec. Geol. Surv. Ind.*, XXXVII, pp. 191—198, (1908).
[2] E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 209, (1909).
[3] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXII, p. 231, (1905).
[4] A. M. Heron, *Rec. Geol. Surv. Ind.*, XLIV, p. 20, (1914).
L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 233, (1906).

TABLE 127.—*Production of Gypsum in India during 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Punjab (Jhelum)	..	..	1,837	*8*	1,469	*7*	1,837	*8*	1,830	*8*	1,395	*6*
Rajputana (Bikanir).	13,715	*705*	4,286	*160*	4,464	*168*	14,440	*755*	19,352	*843*	11,251	*526*
Rajputana (Jodhpur).	3,585	*202*	7,410	*247*	5,000	*281*	4,756	*269*	3,776	*213*	4,905	*242*
United Provinces (Hamirpur).	..	..	.	..	..	..	..	..	3	*7*	(*a*)	(*a*)
TOTAL .	17,300	*907*	13,533	*415*	10,933	*456*	21,033	*1,032*	24,961	*1,071*	17,551	*774*

(*a*) Not taken into average.

in the Kangra Chhu in Bhutan,[1] in association with dolomites; in the Hamirpur district, United Provinces,[2] in limited quantities in the older alluvium, and under similar circumstances in the adjoining parts of the Jhansi district,[3] where it is called *usraith.* Gypsum is also found in Spiti and Kanaur, in the Punjab Himalayas. Between the Lipak and Yulang rivers in Kanaur the gypsum occurs in immense masses and thick beds replacing Carboniferous limestone; it is used locally for whitewash, but the inaccessibility of the deposits would render abortive any attempt to mine the mineral for transmission to the Indian markets.[4]

Marble.[5]

India has long been famous for its marbles, chiefly on account of the fine buildings, such as the Taj Mahal, built from this material by the Moghals. The best known occurrences of white marble are at Makrana in Jodhpur, at Kharwa in Ajmer, Maundla in Jaipur, Dadikar

Occurrence.

[1] G. E. Pilgrim, *Rec. Geol. Surv. Ind.*, XXXIV, p. 28, (1906).
[2] T. D. LaTouche, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 281—285, (1909).
[3] C. A. Silberrad, *Rec. Geol. Surv. Ind.*, XLII, p. 56, (1912).
[4] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 101, (1904).
[5] T. H. Holland, *Journal of the Queen Victoria Indian Memorial Fund*, No. II, March 1904, pp. 18—26.
See also General Report for 1913, *Rec. Geol. Surv. India*, XLIV, p. 16, (1914).

in Alwar, and at Tonkra in Kishangarh, the last-named being dolomitic marble. It is to the coarseness of their grain that these marbles owe in part their resistance to the weather; it is their purity that enables them to maintain their white surface, and it is their translucence that gives them their delicate softness, which could never be obtained from a fine-grained marble more suitable for statuary than for architectural purposes. Similar white marble occurs in unlimited quantities forming the hills of Kyaukse, Sagyin, and Mandalay, on the banks of the Irrawaddy. A coarse white marble is found in Mergui; whilst a saccharoidal dolomitic marble is exposed in large quantities at the far-famed Marble Rocks, forming a beautiful gorge traversed by the Narbaḍa river near Jubbulpore.

Homogeneous yellow marble, and also yellow and grey shell marble, is found at Jaisalmer in Rajputana. Serpentinous limestones, showing green and yellow tints, are found in Ajmer and other places along the Aravalli belt; but the most striking example of this class occurs at Motipura in the Baroda State in the form of a handsome mottled green marble. Very variegated serpentinous limestones occur also in parts of the Cuddapah and Karnul formations in the Madras Presidency, and at several localities in the Nagpur and Chhindwara districts in the Central Provinces.

Pink marbles occur in abundance in the Aravalli belt of Rajputana, and in the Narsinghpur district of the Central Provinces.

Mottled and streaked grey marbles occur in Jodhpur; dark-grey marbles are obtainable in Kishangarh and Jodhpur, while black marble has been found at Bhainslana in Jaipur.

A mottled concretionary dolomitic marble occurs in the Vindhyan series in the Gwalior State, whilst onyx marbles are found at Nurpur in the Shahpur district, and near Jhuli in the Baluchistan desert.

Victoria Memorial.

Extensive tests made in the Laboratory of the Geological Survey on the Makrana marble[1] has shown that it is superior in many respects to the foreign marbles imported from Greece and Italy, and it was therefore decided to employ it in the construction of the Victoria Memorial in Calcutta. Messrs. Martin & Co., contractors for the building, have

[1] Previous review, pp. 261—3.

therefore opened up quarries at Makrana and have erected derricks for bringing the stones to the surface, as well as an extensive plant for cutting and dressing the stone. Considerable difficulty was experienced at first in getting the required quantity of suitable material, but this has now been overcome and a large supply of marble of great beauty is being made available. With the exception of European supervision the work at the quarries is done entirely by indigenous labour and the local artisans have now been trained to turn out carving of a high degree of excellence. Messrs. Martin & Co.'s operations at Makrana were not in a sufficiently advanced stage to have any appreciable effect on the output during the period under review, but the next quinquennial period will witness a considerable increase in production.

Imports.

In spite, however, of the existence of such large supplies of marbles of every variety in different parts of the Indian Empire, there is a large import of marble from abroad, chiefly from Italy and Greece. This is due partly to the great distances that separate the Indian marble deposits from such cities as Calcutta and Bombay, and partly to the systematic organisation of quarrying operations in Europe, by which the cost of foreign marble has been reduced. The foreign imports of stone and marble during the five years 1909 to 1913 averaged 11,893 tons a year, valued at £28,013. On account of the freight advantages attaching to the supply of European marbles, it would probably not pay to lay out much capital on Indian marble quarries; but, with an order sufficiently large to warrant systematic quarrying operations, marble ought to be procurable at a cost that would repay employment in Rajputana, and possibly in Burma. The Rajputana quarries are both protected and hampered by their distance from the sea-board, but in Burma there are hills of marble standing on the banks of the Irrawaddy, and therefore well suited for water transport.

Production.

Marble has for centuries been quarried at Makrana in Jodhpur, the average annual production in recent years having been about 2,000 tons. Marble is also quarried at the State Marble Works about 8 miles from Narnaul Railway Station, Patiala State, where an experimental marble plant has been installed. There is also a small annual production of marble in the Mandalay district for images and pillars, but no figures of production are available.

TABLE 128.—*Production of Marble in Jodhpur, Rajputana, during the years 1909 to 1913.*

YEAR.	Quantity.	*Value.*
	Tons.	£
1909	1,963	*1,247*
1910	2,199	*1,127*
1911	1,857	*1,292*
1912	2,303	*1,426*
1913	2,996	*2,052*
Average .	*2,264*	*1,429*

Mineral Paints.

Up to the present the manufacture of mineral paints appears to be very small in proportion to the demand and the natural resources in minerals apparently suitable. In the Jubbulpore district Messrs. Olpherts & Co. of Katni utilise the soft hematites of Jauli and Messrs. Shaw, Wallace & Co., Calcutta, have worked the yellow ochre of the Panna State: similar works (Messrs. Turner, Morrison & Co.) near Calcutta are dependent largely on imported material.

Such figures as are available are summarized in the following table, in which the values are mostly much understated, being usually the rental or royalty paid. The Central Indian production is derived mainly from Panna, Baraunda, Gwalior, and Sohawal, and that of the Central Provinces from red-ochre pits in the Gangai Zemindari, Drug district, paying an annual royalty of Rs. 354 with a small production from the Balaghat district in 1912 and 1913, and from Jubbulpore in 1913.

Ochres, red, yellow, and of other colours, are commonly used by Indians in many parts of the country, in a crude or simply levigated form, under the generic name *geru*. A common source of supply is laterite in the Peninsula and Burma, but well-defined ochres occur in deposits of various geological ages down to the Archæan hematites. In the Trichinopoly district yellow ochre is obtained from the Cretaceous rocks, and in Burma large deposits are known among the Tertiary beds of the Myingyan district. It is also probable that various grades of ochre, umber, and sienna could be set aside from the 'country' when working the Vizagapatam manganese-ore deposits. A black slate near Kishangarh has been

successfully tried on the Rajputana-Malwa Railway. Barytes, used as a substitute or adulterant for 'white lead,' is obtainable in quantity near Alangayam in the Salem district, and at Sleemanabad in the Jubbulpore district. Small amounts of barytes from the latter locality have been used by Messrs. Turner, Morrison & Co. of Calcutta (see page 237).

TABLE 129.—*Production of Ochre in India during 1909 to 1913.*

—	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Central India .	860	(*a*)	815	(*a*)	*Nil*	..	551	(*a*)	*Nil*	..	845	(*a*)
Central Provinces .	..	..	198	*24*	226	*24*	423	*49*	441	*35*	258	*26·4*
Madras . . .	..	..	..	..	16	*1*	25	*2*	..	..	8	*·6*
TOTAL .	860	..	1,013	..	242	..	999	..	441	..	611	..

(*a*) Value figures not received.

For remarks on the imports into Burma, and application in the arts there, of orpiment, see page 235.

Mineral Waters.

One curious feature in connection with Indian minerals is the neglect of our numerous hot and mineral springs. To what extent the value of these is purely fanciful is a matter of small concern for the time being; for whether they have the medicinal properties claimed for them or not, there is no doubt that well-advertised mineral waters have an economic value, and numerous varieties from Europe and Japan are scattered over India, and brought to the continual notice of the travelling public in all the railway refreshment rooms. Natives of India have for many ages recognised a value in mineral waters and in the hot springs, which are often charged with more than usual quantities of mineral matter. In many cases these, like most unusual natural phenomena, have become sacred to the Hindus, and have consequently become places of resort for pilgrims from great distances. Of instances of this sort may be mentioned the hot springs at Manikarn in Kulu, where the pilgrims cook their rice in the hot springs emerging in the shingle beds close to the ice-cold stream of the Parbati river. The

hot water is also led into the neighbouring temple and rest-house for baths, being supposed to be of value for rheumatism. At Lasundra in the Kaira district, and at Vajrabai in the Thana district, Bombay Presidency, springs of sulphurous water, having a temperature of 115° F., are also resorted to by Hindu pilgrims. Generally it may be said that hot springs, often sulphurous, are common throughout the Tertiary areas of Sind and Baluchistan on one side, and of Assam and Burma on the other side of India, the distribution being similar (and perhaps dependent on similar causes) to the distribution of petroleum, with its constant associates of salt and gypsum. Other springs occur along the foot-hills of the Himalaya, in the Kharakhpur hills, etc., sufficiently well distributed to permit of easy transport. The provincial gazetteers contain sufficient references to these springs to guide private enterprise, but more might be done in the way of analysis of the waters, which would be as interesting from a scientific as possibly from an economic point of view. The mineral water of Sitakund in the Kharakhpur hills is the only one which has been turned to account. An investigation into the radio-activity of the thermal springs of the Bombay and Madras Presidencies has recently been undertaken by Dr. A. Steichen of St. Xavier's College, Bombay.

Nickel.

Ores of nickel (nickeliferous pyrrhotite) have been found amongst the copper-ores of Khetri and other places in Rajputana. Nickel has also been detected in small quantities in chalcopyrite and pyrrhotite found associated with the gold-quartz reefs of Kolar, and in pyrite said to be from the Henzada district of Burma. Complex sulphide ores, consisting of pyrrhotite, pyrite, chalcopyrite, and molybdenite, have been received from the Tobala taluk in South Travancore. Both nickel and cobalt are present in quantities beyond mere traces, but nothing is yet known as to the extent of the deposits, nor have any proper average samples been assayed. A surface sample of ore showed 1·20 per cent. of copper, 0·64 per cent. of nickel, and 0·08 per cent. of cobalt, with 12 grains per ton of gold and 2 dwts. 12 grs. per ton of silver. Further investigations may show that the deposits are richer than is indicated by this analysis.

There is a considerable consumption of nickel in India in the form of German-silver, the annual imports of which during the five years

1909 to 1913 have averaged 1,103 tons worth £115,388 (see page 13). Further, on the 1st August 1907, the issue to the public was commenced of the new 1-anna nickel coinage, consisting of an alloy of 25 parts of nickel with 75 of copper, leading to a further consumption of nickel, statistics for which are not available.

The imports of nickel received at the Bombay Mint during the period 1909-13 have totalled 175·3 tons (4,767 maunds 2,734 tolas) valued at £30,671.

Phosphates.

One regrettable feature in connection with the Indian mineral resources is the absence, in a country where agriculture is such a predominant industry, of any phosphatic deposits of value, and a further circumstance to be regretted is the export of phosphates in the form of bones, due primarily to the fact that the country being without the means for the manufacture of cheap sulphuric acid, superphosphate is not made and the small quantity used is imported from Europe. During the past five years the materials imported under the head of manures have varied in value from £4,939 in 1908-09 to £69,468 in 1913-14, whilst the exports of animal bones have averaged 92,829 tons a year valued at £420,939 (see table 130). Of these imports in the year 1913-14, £11,802 represented various forms of phosphates. In addition manures are obviously also included under the heading 'Ammonia and salts thereof,' the imports of which were valued at £29,390 in 1913-14.

TABLE 130.—*Exports of Manures from India during the years 1908-09 to 1913-14.*

YEAR.	TOTAL MANURES.		ANIMAL BONES.	
	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£
1908-09	96,309	*393,745*	83,309	*345,335*
1909-10	99,842	*417,719*	85,384	*360,110*
1910-11	104,143	*441,812*	83,682	*361,694*
1911-12	111,892	*503,402*	88,963	*410,623*
1912-13	139,967	*646,043*	110,221	*525,739*
1913-14	127,433	*629,870*	105,413	*522,233*
Average	***113,264***	***505,432***	***92,829***	***420,939***

Among the phosphatic deposits of India, the principal, and perhaps the only one worth considering, is the deposit of phosphatic nodules of the septarian kind, occurring in the Cretaceous beds of the Perambalur taluk, Trichinopoly district, Madras Presidency. Dr. H. Warth estimated in 1893 that to a depth of 200 feet the beds contained nodules to the amount of 8 million tons, but the phosphates are distributed irregularly through clay, varying, in the different excavations made, between 27 and 47 lbs. per 100 cubic feet, and in the shallow workings 70 lbs. per 100 cubic feet. Analyses of these nodules show them to contain from 56 to 59 per cent. of phosphate of lime with about 16 per cent. of carbonate. Two attempts made to dispose of these phosphates in a finely powdered condition for use as a fertilizer on coffee plantations in Southern India were, however, reported to be unprofitable, and mining leases have consequently not been applied for. Recent attempts to utilise these deposits for the export of crushed nodules to Ceylon, where there is said to be a considerable demand, have not been crowned with success.

Small quantities of apatite are turned out and thrown away with the waste in the Hazaribagh and Nellore mica-mining areas, and a few other occurrences of unknown, and presumably small, value occur at different places—near Mussoorie, in Eastern Berar, and in the Eocene shales above the coal near the Dandot colliery in the Punjab Salt Range. Apatite in small granules could also be washed out of the decomposed koduritic rocks found in many of the Vizagapatam manganese mines, and might be obtainable thus in some quantity.[1] The rocks of Jothvad Hill in Narukot State, Bombay, are very rich in apatite, but hardly worth treating.[2]

Rare Minerals.

It is only within recent years that the minerals of the so-called rare metals have received attention in India. During the last ten years considerable attention has been directed to such minerals by prospectors, with the resultant discovery of several minerals not known previously to occur in India. Of these wolfram and monazite have now furnished the materials for established industries (see pages 222 and 188), while others, referred to below, are not yet known to occur in quantities large enough for serious exploitation.

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 251, (1909).
[2] *Ibid.*, p. 648.

Molybdenum.

Molybdenite, the sulphide of molybdenum, has been found in the wolfram-bearing veins of Tavoy and Mergui, but so far the amount found is not large, although there are indications that deposits of economic value may be present. It also occurs, in the crystalline rocks and in quartz, in various parts of Chota Nagpur, and also in an elæolite-sodalite-cancrinite pegmatite in Rajputana, at Mandaoria, near Kishangarh. Molybdenite also occurs disseminated through the Travancore pyrrhotites noticed under the heading of nickel (see page 281), and might possibly be worth separating from the ores, should these ever be worked for copper and nickel.

Platinum and iridium.

Platinum and iridosmine have been found in the auriferous gravels of the rivers draining the slopes of the Patkoi ranges, both on the Assam and the Burma sides. The former metal is also obtained, with gold, by the Burma Gold-Dredging Company from the gravels of the Irrawaddy above Myitkyina. During the years 1911-13, 152 ounces, valued at £954, were won by that Company.

Columbite and tantalite.

Columbite (niobate of iron and manganese) and tantalite (tantalate of iron and manganese) have been found at several localities in the mica-bearing pegmatites of India. There is, of course, a perfect gradation from columbite to tantalite owing to a gradual replacement of niobium (or columbium) by tantalum, with a corresponding increase in specific gravity, and at any locality where one of these minerals has been found one may reasonably look for the other. Tantalite is of much greater value than columbite on account of the demand for tantalum for manufacturing the metallic filaments in the Tantal incandescent lamp; and, consequently, the value of samples of columbite and tantalite depends on the percentage of tantalum present, usually expressed as the oxide Ta_2O_5. These minerals have been found in the districts of Gaya (at Singar), Hazaribagh (near Kodarma), and Monghyr (at Pananoa Hill), in Bihar and Orissa; in the districts of Madura, Nellore (at Chaganum), and Trichinopoly (near Vaiyampatti), in Madras; and at Masti in the Bangalore district, Mysore.[1] 112 lbs. of columbite were produced in Mysore in 1913.

At Pananoa Hill near Jhajha (Nawadih) Railway Station, East Indian Railway, both columbite and tantalite are found, two specimens of the latter received in the Geological Survey Office having

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 204, (1909).

the very high specific gravities of 6·75 and 6·92; assays have shown 37 per cent. and 52 per cent. of Ta_2O_5 respectively.

Some years ago Mr. C. Middleton of Trichinopoly discovered, when excavating for mica in the Semmallai Hills near Vaiyampatti in the Trichinopoly district, a mineral which he had assayed in London in 1908, with the discovery that it was tantalite containing 66 per cent. of Ta_2O_5. A specimen received in the Geological Survey Office proved to be nearer columbite than tantalite.

Titanium.

Ilmenite, or titaniferous iron-ore, occurs as small masses and isolated crystals in various parts of the charnockite series and pyroxene-granulites of Peninsular India. It is found in abundance in the monazite beach sands of Travancore. About 3 miles south of Kishangarh in Rajputana large crystals of ilmenite, 2—3 inches in diameter, are found associated with clear calcite crystals forming a broad vein in the granitoid gneiss. This ore was at one time smelted in the local native furnaces.

Rutile, one of the natural forms of titanic oxide, is widely distributed throughout many of the crystalline schists. It has been found in pieces of some size during exploratory work for mica in the neighbourhood of Ghatasher in the Narnaul district of Patiala State, Punjab.[1] Mr. Bose also reports the occurrence of this mineral in the vicinity of Kadavur in the Trichinopoly district of Madras.

Uranium (pitchblende and samarskite).

The occurrence of the uranium-ore, pitchblende, or uraninite, with the other uranium minerals torbernite and uranium-ochre, at the Singar mica mine in the Gaya district, Bihar and Orissa, and also of considerable quantities of triplite, a phosphate of iron and manganese, has been known for some years.[2] The locality was subsequently visited by Mr. R. C. Burton [3] of the Geological Survey, who found that the pitchblende occurs as nodules in the pegmatite, one nodule weighing as much as 36 lbs. Prospecting operations have not yet revealed any large deposit.

The very rare mineral samarskite has been found in a mica-bearing pegmatite near Gridalur village, Nellore district, Madras.[4] Altogether 56 cwts. were won during the period under review.

[1] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59, (1906).
[2] T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 31, (1901).
[3] R. C. Burton, *Rec. Geol. Surv. Ind.*, XLIV, p. 31, (1914).
[4] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 342, (1910)

Samarskite is a very complex niobate and tantalate, chiefly of uranium, the yttrium earths, and iron.

Yttrium earths.

Of minerals containing the yttrium earths in considerable quantity, samarskite (see above) and gadolinite have been found. The latter, which is a silicate of the yttrium earths, beryllium, and iron, occurs in a tourmaline-pegmatite, in association with cassiterite, in the Palanpur State, Bombay Presidency.[1]

Zirconium.

Zircon, or zirconium orthosilicate, is found in nepheline-syenites near Kangayam in the Coimbatore district, Madras, and with the triplite of Singar in Gaya (see previous page).

Slate.

Slate-quarrying gives a means of livelihood to numbers of workers along the outer Himalayas, where the foliated rocks, though often not true clay-slates, possess an even and perfect fissility, which enables them to be split for slabs and even fine roofing slates at Kanyara. In the Kangra district, work is being carried on in a systematic manner by the Kangra Valley Slate Company, Ltd, which during the five years ending the 31st December 1913 has declared dividends averaging 21 per cent. per annum with the addition of considerable sums to the reserve funds. The same Company works quarries in clay-slates amongst the Aravalli series near Rewari in the Gurgaon district south of Delhi. Another company working in the Kangra district is the Bhargava Slate Company.

In the Kharakhpur Hills, Monghyr district, Bihar, the properties held by Messrs. C. T. Ambler & Co. were transferred to a limited company, Ambler's Slate and Stone Company, in 1913. The slate worked is often slightly phyllitic and is probably of Dharwarian age. Though not giving the thinnest varieties of roofing slate, these quarries produce fine slabs for which a more extended use is continually being found for flooring, roofing, ceilings, and for small dishes and curry platters for native use. Enamelled slate slabs for electrical purposes are also manufactured. Some of the quarries held by this company date back to ancient times, and probably yielded the very fine piece of slate from which the throne of the Nawabs Nazim of Bengal, now shown in the Indian Museum, was fashioned.

[1] T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXI, p. 43 (1903).

Slate is also being worked in various parts of the so-called transition series of rocks of the Peninsula; such figures as are available to show the extent of the trade are given below (table 131) with the figures of production of the two companies already mentioned. The figures returned by the Nizam's Government, Hyderabad, show the annual production of a substance returned as 'slabstone'; but whether this 'slabstone' is slate or not is not known. The output of the United Provinces is derived from the Almora and Garhwal districts.

TABLE 131.—*Production of Slate during 1909 to 1913.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa—Monghyr (*a*) .	1,423	*1,836*	1,300	*1,362*	1,014	*1,300*	2,000	*2,460*	2,650	*2,820*	1,677	*1,956*
Manbhum .	95	*40*	.	..	.	..	..	..	..	..	(*c*)	..
Burma—Kyaukse .	26	*3*	153	*82*	..	..	..	..	..	..	(*c*)	..
Hyderabad .	(*d*)	*1,071*	(*d*)	*1,331*	(*d*)	*1,053*	(*d*)	*953*	(*d*)	*1,079*	(*d*)	*1,097*
Punjab—Gurgaon (*b*) .	1,931	*1,344*	1,857	*1,213*	2,009	*1,327*	2,976	*2,146*	3,553	*2,680*	2,465	*1,742*
Kangra (*b*) .	3,700	*4,267*	7,682	*6,833*	4,112	*5,096*	5,015	*5,640*	5,267	*5,778*	5,155	*5,923*
United Provinces	(*d*)	*658*	(*d*)	*9*	(*d*)	*36*	(*d*)	*554*	(*d*)	*313*	(*d*)	*314*
TOTAL .	..	*9,219*	..	*12,830*	..	*8,812*	..	*11,753*	..	*12,670*	..	*11,032*

(*a*) Output by Ambler & Co. for 1909 to 1912 and first three months of 1913; and by Ambler's Slate and Stone Co., Ltd., for the last nine months of 1913.
(*b*) Output by the Kangra Valley Slate Co., Ltd.
(*c*) Not taken into average.
(*d*) Weights not available.

Sodium Compounds.

Besides sodium chloride, other salts of soda, notably the sulphate (*khari*) and carbonate (*sajji*), accumulate in the soil of areas where the climate is dry, giving rise to the alkaline efflorescence known as *reh*, which renders large areas quite sterile. Both the sulphate and carbonate are also prominent amongst the sodic compounds in the brine of the Rajputana Salt Lakes. Carbonate of soda occurs in quantity in the water of the Lonar Lake referred to below.

Imports.

There was formerly a considerable production of both salts for consumption in India, but the native material is now being displaced by the cheap supplies of chemically manufactured material obtained from Europe. The total imports of soda salts have increased from about £70,000 in 1905 to £212,649 in 1913. The imports of sodium bicarbonate during the quinquennial period averaged 86,357 cwts., valued at £30,470, whilst the imports of caustic soda averaged 91,271 cwts., valued at £54,144. The annual total imports of soda salts averaged 525,803 cwts., valued at £186,393.

For information concerning the alkali compounds used and manufactured in India, reference may be made to the *Agricultural Ledger*, No. 5 of 1902, published by the Reporter on Economic Products, Calcutta. Other numbers of the Ledger give information about *reh*. These interested in *reh* lands should also consult Dr. J. W. Leather's 'Investigations on Usar Land,' Allahabad, (1914).

Sodium sulphate.

Sulphate of soda or *khari* is obtained as a bye-product in the manufacture of saltpetre from the soil in Behar, but the only districts from which returns of production have been obtained are Saran, Champaran, and Mozaffarpur. The two former districts yielded the surprisingly large total average production for the four years 1910 to 1913 of 30,354 tons valued at £66,570. The details are shown in table 132. The figures for the Mozaffarpur district relate to the years 1908-09 to 1912-13 and show an annual average production of 231 tons of *khari* valued at £473.

TABLE 132.—*Production of Sulphate of Soda in Bihar and Orissa during 1908-13.*

YEAR.	CHAMPARAN.		MOZAFFARPUR.		SARAN.		TOTAL.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	**Quantity.**	*Value.*
	Tons.	£	Tons.	£	Tons.	£	**Tons.**	£
1908-09	987	*1,974*	6,615	*13,608*	1,715	*3,430*	**9,317**	*19,012*
1909-10	2,822	*5,644*	13,363	*7,126*	4,683	*9,366*	**20,868**	*22,136*
1910-11	2,969	*5,938*	14,409	*29,641*	5,311	*10,622*	**22,689**	*46,201*
1911-12	2,176	*4,352*	11,672	*18,383*	3,943	*7,886*	**17,791**	*30,621*
1912-13	2,283	*4,566*	12,263	*19,314*	3,446	*6,892*	**17,992**	*30,772*
AVERAGE	2,247	*4,495*	11,665	*17,614*	3,819	*7,639*	17,731	*29,748*

Lonar Lake.

The proposal to utilise the incumulations of soda salts in the Lonar Lake (19° 59′ : 76° 33′) in the Buldana district, Berar, has been frequently raised, but the place is too inaccessible at present for anything like development on a large commercial scale. This lake was investigated by Messrs. T. H. D. LaTouche and W. A. K. Christie in 1910.[1] The lake lies in a depression in the Deccan Trap, and its origin, though not satisfactorily explained, has been regarded as probably similar to that of the so-called 'explosion craters' of the kind described by R. D. Oldham in the Lower Chindwin district.[2] Mr. LaTouche, however, regards it as due to the collapse of a gigantic blister caused by vapour or molten rock. The depression is nearly circular, about a mile in diameter and 300 feet deep; at the bottom there is a shallow lake of saline water, which is variable in density and quantity according to the season of the year. The most prominent salts in solution are the carbonate and chloride of sodium, the former being in excess and often found separated on account of supersaturation, when it takes the mineralogical form of *trona* or *urao*, $Na_2CO_3.NaHCO_3.2H_2O$. A series of analyses by F. J. Plymen of the various crystallised products indicate the presence of the following percentage proportions of soda salts (a small portion of the soda being replaced by potash):—

——	Bhuski.	Papri.	Khappal.	Dalla.	Dalla Nimak.	Nimak Dalla.
Na_2CO_3 . .	32·72	23·19	24·09	46·90	33·05	11·67
$NaHCO_3$ . .	27·53	17·21	18·18	33·18	26·09	8·58
$NaCl$ . .	3·35	41·99	37·45	..	24 25	71·11

In each case the ratio of carbonates is very close to that required for the urao formula, and sufficient water of crystallisation is also present. Dr. Christie calculated that in March 1910 the brine contained about 2,000 metric tons of alkali reckoned as sodium carbonate and that the superficial 1·5 metres of mud (with an alkalinity equivalent to 0·26 per cent. of sodium carbonate) contained some 4,500 tons of sodium carbonates. In the absence of borings

[1] *Rec. Geol. Surv. Ind.*, XLI, pp. 266—285, (1912).
[2] *Rec. Geol. Surv. Ind.*, XXXIV, p. 137, (1906).

the depth to which such mud persists is unknown. The presence of the sodium carbonate in the lake water is regarded as due to concentration by evaporation of stream waters in the absence of an exit from the lake, whilst the chloride is regarded as in part wind-borne from the sea-coast.

Considerable quantities of soda salts were recovered from this lake in the old days for use in the manufacture of soap and glass; but, since the principal markets for soda are now served by the cheaper and purer products of the European chemical manufacturer, there is little demand for the impure salts from Lonar. Suggestions are offered for improving the methods of manufacture, but even under the most favourable conditions the industry could never become an important one, owing to the limited resources of the lake.

The total output of soda salts from Lonar during the quinquennium 1909-13 is estimated to be as follows:—

							Rs.
Dalla .	. 3,000	maunds	(110 tons)	valued at	Rs. 2	per maund . .	6,000
Khappal .	. 3,000	,,	,,	,,	Re. 1-8	,, . .	4,500
Papri .	. 6,000	,,	(220 tons)	,,	Re. 1	,, . .	6,000
Nimak Dalla .	175	,,	(6½ tons)	,,	Re. 1-4	,, . .	219
TOTAL	. **12,175**	**maunds**	or **446½ tons**	**valued at**			**16,719** or **£1,115**

Steatite.

One of the most widely distributed minerals in India is steatite, either in the form of a coarse potstone—so called on account of its general use in making pots, dishes, etc.—or in the more compact form suitable for carvings, and in its best form, suitable for the manufactue of gas-burners. There is a trade of undetermined value in nearly every province, but it is in most cases impossible to form even a rough estimate of its value. An exhaustive account of the Indian occurrences of steatite was published by Mr. F. R. Mallet in the *Records, Geological Survey of India,* Vol. XXII, part 2 (1889); and a later [1] note adds further details with regard to the deposits in Minbu district, Burma. In 1911-12, Mr. C. S. Middlemiss [2] discovered a large deposit of steatite of very fair quality near Dev Mori in Idar State, Bombay Presidency, asso-

[1] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXIX, p. 71, (1896).
[2] *Rec. Geol. Surv. Ind.*, XLII, p. 52, (1912).

ciated with various other magnesian minerals (actinolite, magnesite, serpentine, asbestos). He estimates that bed of steatite to be over 1 mile with a width of over 200 feet and a vertical dip. On this basis it is calculated that 2 million tons are obtainable in the first 20 feet from the surface. Mr. A. M. Heron has collected notes on some hitherto undescribed steatite deposits in Jaipur State, Rajputana.[1]

Such figures as are available for the output of Indian steatite are summarised in table 120. The values assigned to the mineral vary between very wide limits, and although this is no doubt partly due to differences in the value of the product according to the use to which it is put, yet some of the figures are probably but rough estimates.

The steatite deposits on the north side of the Marble Rocks in the Jubbulpore district, which were formerly worked by native methods with a small annual production, have now been taken up on mining lease by Messrs. P. C. Dutt and Burn & Co.; the latter have now erected a grinding mill in their pottery works at Jubbulpore and are converting their steatite into powder whilst deposits at Gowari and Lalpur on the south side of the Narbada have been secured by the Bombay Mining and Prospecting Syndicate.

TABLE 133.—*Production of Steatite during the years 1909-13.*

PROVINCE.	1909.		1910.		1911.		1912.		1913.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	
Bihar and Orissa (b)	..	..	..	..	(a)	*26*	(a)	*83*	1,056	*369*	211	*144*
Burma (c)	18	*477*	13	*663*	1	*9*	19	*195*	..	..	10	*269*
Central Provinces. (d)	565	*769*	153	*209*	441	*58*	560	*560*	661	*378*	476	*501*
Hyderabad	(a)	*13*	(a)	*2*	(a)	*14*	(a)	*14*	(a)	*12*	(a)	*11*
Madras (e)	..	..	28	*101*	292	*561*	48	*25*	579	*4,489*	189	*1,035*
United Provinces (f)	..	..	50	*133*	186	*587*	161	*649*	228	*1,452*	125	*564*
TOTAL	**583**	*1,259*	**244**	*1,108*	**920**	*2,026*	**788**	*1,526*	**2,524**	*6,700*	**1,011**	*2,524*

(a) Quantities not returned.
(b) Singhbhum, Seraikela, and Mayurbhanj.
(c) Minbu, Myitkyina, and Pakokku.
(d) Jubbulpore.
(e) Karnul, Nellore, and Bellary.
(f) Hamirpur and Jhansi.

[1] *Rec. Geol. Surv. Ind.*, XLIII, p. 21, (1913).

The annual output from this area during the period averages 476 tons valued at £501.

The Burmese production comes from the Minbu, Pakôkku Hill Tracts and Myitkyina districts, and is used for pencils; hence its high value. The decreasing production is said to be due partly to the gradual replacement of the steatite pencil by pen and paper, and partly to the exhaustion of the deposits.

During the quinquennium, Mr. A. Ghose has continued to open up the steatite deposits at Muddavaram and Musila Cheruvu near Betamcherla in the Karnul district, taking out a mining lease in 1912. A market has been obtained in America and on 158 tons exported in 1913, the prices obtained ranged from £7 for 'nugget' steatite to £14 per ton for block steatite, c.i.f. New York or European ports, most of the output of this year being white steatite from Musila Cheruvu. The larger portion of the steatite of this locality is green, and has fetched a price of £10 a ton. At Muddavaram the steatite is ivory white associated with quartzose rock and magnesite and is suitable for small articles, such as gas-burners.

Sulphur, Sulphuric Acid and Soluble Sulphates.

Sulphur.

Small quantities of sulphur are obtainable on the dying volcano of Barren Island, and on some of the volcanoes in Western Baluchistan, whilst it has been reported in connection with the petroliferous Tertiary rocks in the Baluchistan-Persian belt, as well as in the Arakan system on the east. There are, however, no deposits of free sulphur known to be worth working.

Pyrite is known in various parts of India, and in one place, near Kalabagh on the Indus, it is sufficiently abundant in the shales, which have been worked for alum (see page 227) to give rise to frequent cases of spontaneous combustion. An occurrence of this sort is one that, suitably placed, might be of value as a source of sulphur. Otherwise, the only chance of sulphur to compete with the imported article is bound up in the problem of developing the metalliferous sulphides for both metal and sulphur.

Sulphuric acid.

In view of the value of the imports of sulphur and sulphuric acid, and in consideration of the fact that a cheap supply of the acid would be the key to many industries now either non-existent or in a

feeble condition, the manufacture of sulphuric acid on a large scale and cheaply would be the starting point of an economic revival.

During the six years, 1908-09 to 1913-14, the imports of sulphur have averaged 98,261 cwts. a year, valued at £31,575, as compared with an annual average of 63,433 cwts., valued at £20,516, for the period of the previous review. The average annual import of sulphuric acid was 61,774 cwts., valued at £38,15³, as compared with 62,969 cwts., valued at £44,110, for the period of the previous review. Of these imports, there has been average annual re-export of 780 cwts., largely to Persia. In addition to sulphuric acid there are several chemicals imported that could be produced more cheaply in India if the acid were made in the country in large quantities at a sufficiently low price. The average annual value of imported bleaching materials alone, during the five years 1909-10 to 1913-14, has been £26,976.

On the Giridih coalfield, bye-product recovery coke-ovens, with an annual production capacity of 40,000 tons of coke, have recently been erected and set into operation (in 1909).[1] The ammonia is, of course, converted into ammonium sulphate, the annual production of which amounts to 360 to 400 tons. At first a portion of this was exported to Java, but almost the whole of it is now consumed by sugar plantations in India and Ceylon. It is to be hoped that the success of this experiment will stimulate other coal companies to erect similar plant and prevent the great waste of bye-products now taking place in the manufacture of coke in Bengal; this will, of course, still further increase the demand for sulphuric acid. With the discovery of highly aluminous bauxites, it should now be possible to manufacture impure aluminic sulphate and alumino-ferric cake for use in the dye-works of the country. There are now several sulphuric acid factories at work in the Nilgiris (the Government Cordite Factory), near Madras (Messrs. Parry & Co.), near Calcutta (Messrs. Waldie & Co. and the Bengal Chemical and Pharmaceutical Co.), and in Cawnpore (Messrs. Waldie & Co.).

The approximate amount of sulphuric acid of all strengths manufactured by Messrs. Waldie & Co. during the period under review was about 1,300 tons per annum. The acid is produced by the ordinary 'chamber' process from sulphur imported from

[1] T. H. Ward, *Rec. Geol. Surv. Ind.*, XXXI, pp. 92—100, (1904). T. H. Holland, *ibid.*, pp. 100—102; *Trans. Min. Geol. Inst. Ind.*, II, p. 47, (1907).

Sicily. It is concentrated to specific gravities of 1·840, 1·800, 1·740, and 1·700.

Sulphuric acid has been manufactured by the Bengal Chemical and Pharmaceutical Works, Ltd., since 1907, the raw materials used being Sicilian sulphur and Indian saltpetre. The present daily capacity of these works is about 5,000 lbs. of acid, but the works are being extended to allow of the daily production of 7,000 lbs. of acid. The production of these works since 1909 is as follows:—

	Tons.
1909	161
1910	241
1911	267
1912	321
1913	482
1914	723

A small portion of the acid is used in the manufacture of nitric and hydrochloric acids; successful experiments have been carried on at these works for the manufacture of alum and ferro-alum from Katni bauxite and of bleaching powder from pyrolusite from the Central Provinces. The increased demand is due to the advent of new industries, such as the galvanizing of sheet iron and the manufacture of ammonium sulphate from wash water from gas works. There is also a consumption of sulphuric acid at the above works for converting Indian magnesite into magnesium sulphate.

In the year 1908, a company entitled the Burma Chemical Industries, Ltd., with an issued capital of Rs. 2,50,000, was floated for the purpose of erecting sulphuric acid plant in or near Rangoon. The original plant, consisting of four leaden chambers with Glover and Gay-Lussac towers, was designed for a daily production of 10 tons of acid of 1·84 specific gravity, from Japanese and Sicilian sulphur. The acid was concentrated in a Kessler plant, and put up in cast-iron drums. The daily capacity of the plant has now been increased from 15 to 18 tons by the addition of a Gaillard Concentrating Tower to replace the Kessler plant and by the erection of a large Glover tower and conversion of the old one into a second Gay-

Lussac tower. The annual production of these works is as follows :—

	Tons.
1910	175
1911	2,017
1912	2,680
1913	3,432

There is a considerable consumption of sulphuric acid in Burma for the refining of petroleum products. This acid has hitherto been imported from Europe, and Indian producers of sulphuric acid have not been able to supply the Burmese demand on account of the difficulty of providing lead or other suitable cases for the transport of the acid by sea from Calcutta or Madras.

Sulphates of iron and copper.

For many years pyritous deposits in India have been turned to account for the manufacture of soluble sulphates of iron and copper. The case of alum has been referred to already (*supra*, page 227), and with the alum, which was formerly obtained in quantity from the decomposed pyritous shales at Khetri and Singhana in Rajputana, copperas and blue vitriol were also obtained. No statistics are, however, available with regard to the history of these industries, which have had to give way to the importation of cheap chemicals from Europe.

Being practically the end of the Review this is a convenient place to point the lesson taught by a general survey of progress (*cf.* page 10). Sulphuric acid is the key to most chemical and to many metallurgical industries; it is essential for the manufacture of superphosphates, the purification of mineral oils, and the production of ammonium sulphate, various acids, and a host of minor products; it is a necessary link in the chain of operations involved in the manufacture of the alkalies, with which are bound up the industries of making soap, glass, paper, oils, dyes and colouring matters; and as a bye-product, it permits the remunerative smelting of ores which it would be impossible otherwise to develop. During the last hundred years the cost of a ton of sulphuric acid in England has been reduced from over £30 to under £2, and it is in consequence of the attendant revolution in the European chemical industries, aided by increased facilities for transport, that in India the manufacture of alum, copperas, blue vitriol, and the alkalies have been all but exterminated; that the export trade in nitre has been

reduced instead of developed; that copper and several other metals are no longer smelted; that the country is robbed every year of over 90,000 tons of phosphatic fertilisers; and that it is compelled to pay over 20 millions sterling for products obtained in Europe from minerals identical with those lying idle in India.

Although sulphuric acid and the alkalies are essential to so many other industries, the conditions for their profitable manufacture will balance the 'protective' effect of transport charges only when there is a market in the country for the bye-products which are now essential parts of the cycle of operations in a chemical industry. These conditions, as shown by the import statistics, are rapidly ripening, but the enterprising capitalist should remember, also, that the present requirements of India represent but a fraction of the consumption that will follow any material reduction in prices by local production.

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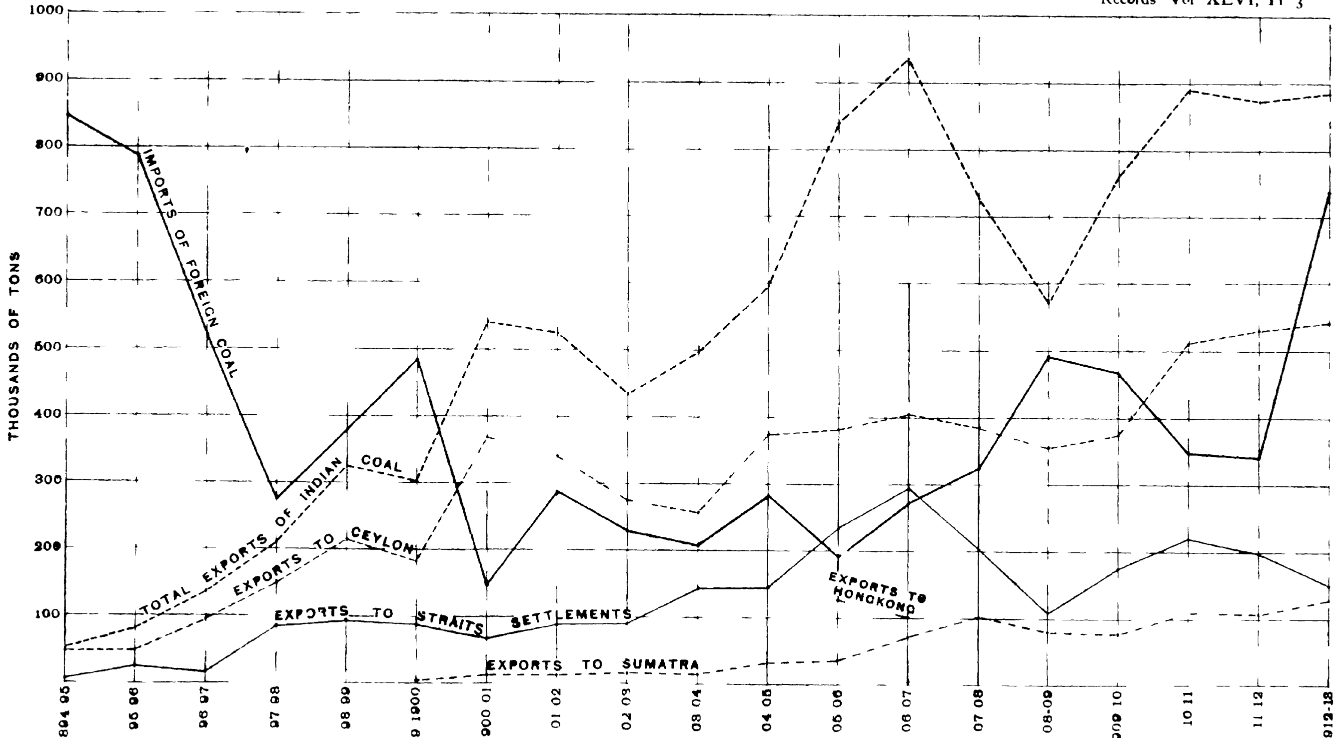
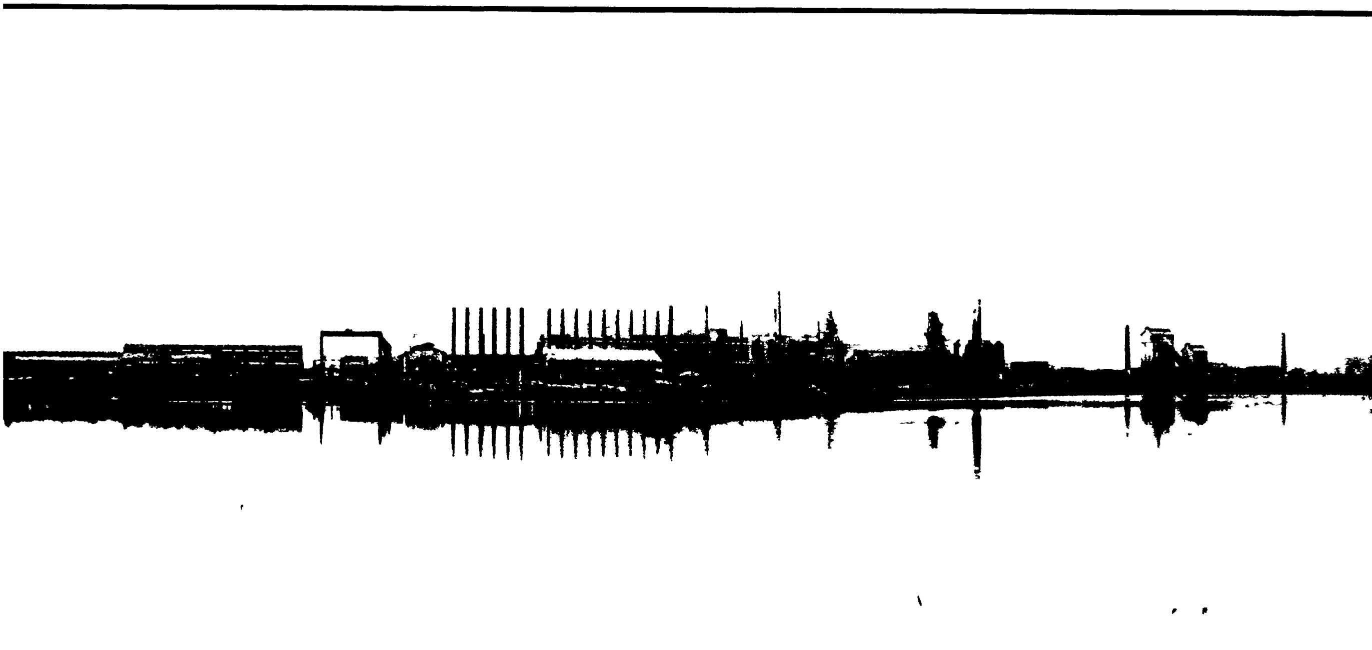


DIAGRAM SHOWING THE IMPORTS OF FOREIGN AND EXPORTS OF INDIAN COAL DURING THE PERIOD 1894—1913

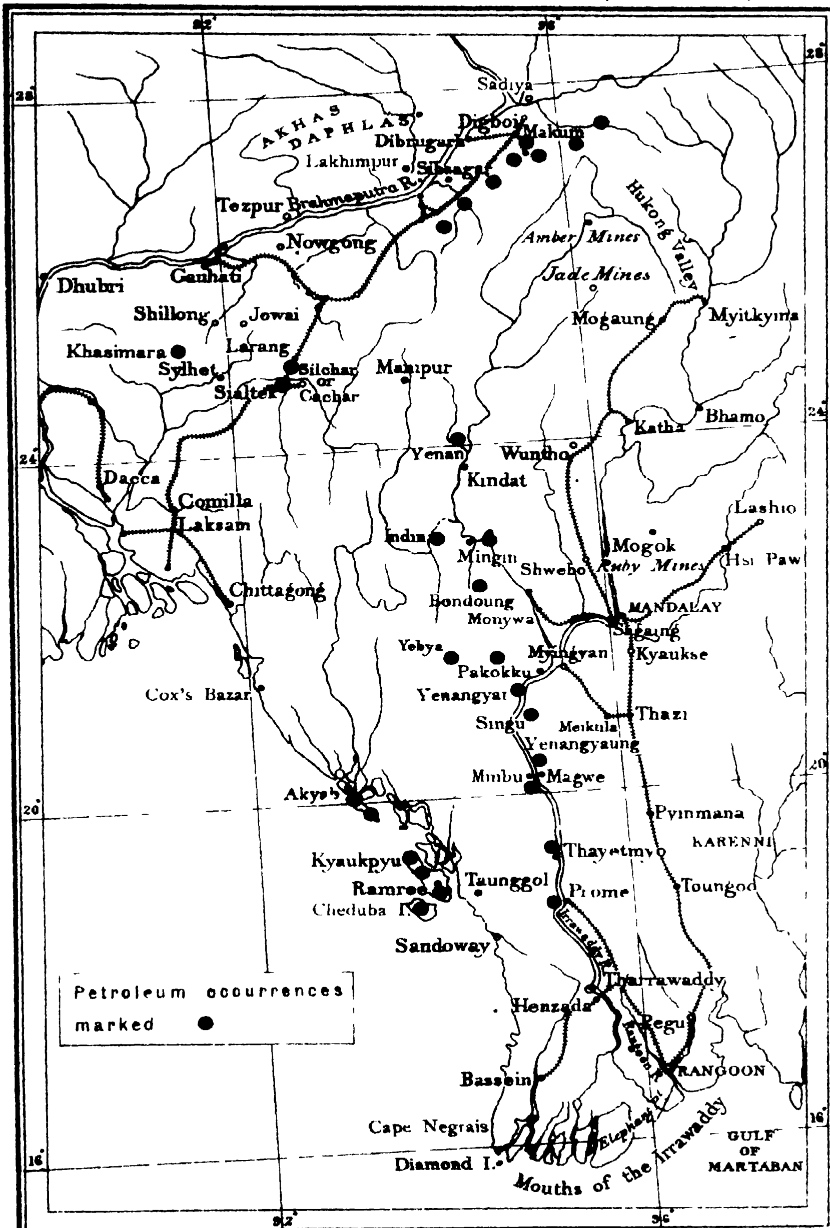
Litho G S I Calcutta



G. S I. Calcutta

GENERAL VIEW OF THE TATA IRON AND STEEL WORKS, SAKCHI

(From a photograph kindly supplied by Messrs. Tata Sons & Co.)



OCCURRENCES OF PETROLEUM IN ASSAM AND BURMA.

(Scale, 1" = 128 miles.)

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